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A METHOD OF DETERMINING THE HEIGHTS OF MIGRATING BIRDS.

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FOR POPULAR ASTRONOMY.

It has long been known to ornithologists that valuable data in regard to the migration of birds at night can be obtained by watching the Moon with a telescope at the proper season, and noting the number of birds which pass before the bright back ground of the Moon's disk. When the Moon is full at the height of the migrating season, several hundred birds can be counted in a few hours by a single observer.

During the past spring and fall, Dr. F. W. Carpenter of the zoological department of the University of Illinois, and the writer have put into practice an extension of this method, using two telescopes stationed some distance apart, and we have succeeded in measuring the heights of the migrating birds. The problem is evidently the determination of the "parallax" of each bird, with the distance between the observers as a base line.

The instruments were two small equatorials of four and three inches aperture, the first on a fixed pier, and the second on a movable tripod giving the choice of any direction or length for the base line. The eyepiece of each instrument gave a power of about twenty-five, and the field of view included all of the Moon's disk. Four heavy cross hairs were placed in the focal plane, dividing the field into octants, and this reticule was rotated in the tube until one of the hairs was parallel to the diurnal motion.

Each observer kept the intersection of the cross hairs on the center of the circular arc of the Moon's image, and when a bird was seen by both, its path was charted by estimation from different cross hairs. A separate chart was kept by each observer and the work was made entirely independent, but the results were compared from time to time to be sure that the base line was long enough. When it was too short, a bird appeared nearly in the same direction from the two stations, and its distance and height could not be well determined. On the other hand, when

the observers were too far apart, the parallax was more than the Moon's diameter and both observers could not see the same bird. As the distances of the birds were unknown in advance, it required some experimenting to determine the best base line. Ten feet was found to answer the requirements when the Moon was near the meridan. For simplicity in both observation and computation we chose to place the instruments in an east and west line, or at right angles to the direction the birds would probably fly, north in the spring, and south in the fall.

Our charts were on a scale of 10 cm. to the Moon's diameter, and the elliptical terminator was drawn when necessary.

We observed on several nights in both seasons, and were most successful on May 19 and October 10, 1905. In two hours and a half on the first date, 78 separate birds were seen, 34 by Dr. Carpenter, 33 by the writer and 11 by both observers. On October 10, in two hours, 29 were recorded by Dr. Carpenter, 17 by the writer and 11 by both, a total of 57. There is no doubt that the observers were far enough apart to miss simultaneous observations of most of the birds, and we feel sure that we reached and determined the upper limit at which birds were flying on these two nights.

Fig. 1. is taken from the charts of May 19, 1905. The circle represents the Moon's disk, the line *L R*, the cross hair parallel

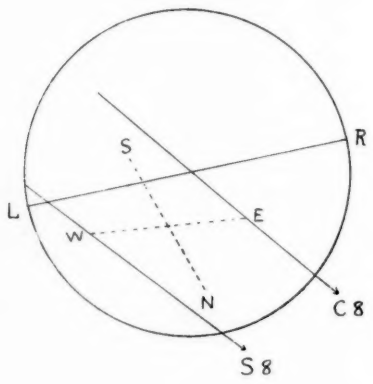

Fig. 1.

to the diurnal motion, the Moon moving from *R* to *L*. The lines *S 8* and *C 8* represent the path of the eighth bird as charted by the two observers, *S* being 21 feet east of *C*. Dotted lines show-

ing directions were computed afterwards. *C*'s chart shows that the bird was best observed in the latter part of its path across the Moon's disk and this was often the case.

If the data were absolutely accurate, the height and direction of flight could be rigorously computed. It is evident that each observer and the line of the bird's path determine a plane. Choosing rectangular axes with origin at one observer, and from the known altitude and azimuth of the Moon, it is possible to derive the equations of each plane, and therefore the equations of the line of their intersection, the bird's path. For example, if the Moon were due east and one observer saw a bird flying apparently straight upwards, he would be unable to tell whether the path was horizontal, and the bird flying due west, or whether the bird was actually rising vertically. In fact, almost any diagonal upward path in a vertical east and west plane would be a possible solution. Another observer properly situated could decide the question. In practice we have found the estimates only approximate, the above rigorous method giving indeterminate results, and we have been forced to assume that the flight of each bird was horizontal. This assumption should introduce little error in the long run, and moreover can have no effect upon the computed height, only the resulting direction being involved.

On the assumption of horizontal flight, the following method has been devised. The angular distance between the apparent paths of a bird, measured along the projection of a line parallel to the line joining the observers, is evidently the angle at the bird subtended by the two observers. When this angle or "parallax" is known, there remains to be computed only the distance from observers to bird, and then the height of the bird above the ground. The main problem then is to find the direction of the line $W\,E$ on the chart, Fig. 1, that is the projection of a west and east line at the bird.

In Fig. 2 let O represent the position of one of the observers, B that of a bird. Choose rectangular axes with orgin at B and let positive x be toward the north, y toward the east, and z toward the zenith. The coordinates of the observers are x, y and z, z being negative. Choose another set of axes $B\,O=y'=r$, z' in the plane $O\,B\,z$ and perpendicular to r, and x' perpendicular to r and z'. Note that x' is also perpendicular to z and therefore horizontal. As the observer looks from O toward B, z' appears vertical, and x' horizontal, both in the plane normal to the line of sight. It is required to find the projection of y upon this plane, call it y''.

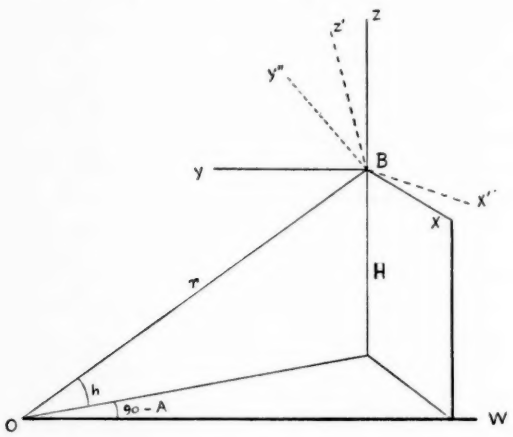

FIG. 2

Let $(r\,y)$ denote the angle between the lines r and y, etc. Then by projecting out on the celestial sphere it may be easily seen that

$$\cos(r\,y) = \cos h \sin A$$
$$\cos(x'y) = -\cos A$$
$$\text{and } \therefore \quad \cos(z'y) = \sqrt{1-\cos^2 h \sin^2 A - \cos^2 A} = \sin h \sin A.$$

If the direction cosines of any line, r, with respect to three rectangular axes x, y, and z, are l, m, n, respectively, we have from analytical geometry, the angle which the projection of r on the $x\,z$ plane, call it r', makes with the z axis, is given by

$$\cos(z\,r') = \frac{n}{\sqrt{1-m^2}}$$

We have therefore

$$(1) \qquad \cos(z'y'') = \frac{\sin h \sin A}{\sqrt{1-\cos^2 h \sin^2 A}}$$

In the same manner may be derived for the projection of x on the $x'z'$ plane

$$(2) \qquad \cos(z'x'') = \frac{\sin h \cos A}{\sqrt{1-\cos^2 h \cos^2 A}}$$

As the telescopes were mounted equatorially, z' was not marked in the field, and we have to connect it with the direction of LR, Fig. 1. In the field of an inverting telescope z' is directed downward. Let Rz' be the angle in the field between LR and z', then

$$(3) \qquad \begin{aligned} Rz' &= 90^\circ - q \\ LW = RE &= 90 - q - (z'y'') \\ LS = RN &= 90 - q \mp (z'x'') \end{aligned}$$

where q is the parallactic angle of spherical astronomy. The

double sign refers respectively to east or west of the meridian.

By means of these formulæ the direction of y'' or WE, also SN, was computed for Fig. 1. Remembering that the observers were in an east and west line, the angular length WE is seen to be the parallax of the bird.

Let d be the distance in feet between the observers, B the angular length of WE and H the height of the bird from the ground. Then from Fig. 2

$$\cos(ry) = \cos h \sin A$$
$$(4) \qquad r = \frac{d \sin(ry)}{\sin B}$$
$$H = r \sin h.$$

it being permissible to consider r and h the same for each observer.

The computation of the angles h, A and q is familiar to any student of spherical astronomy. We have

$$\theta = M + Q.$$
$$t = \theta - \alpha.$$

where θ is the sidereal time, M, mean time, and Q the difference between them; t, hour angle and α, right ascension of the Moon. At this observatory we have tables giving h, A, and q to the nearest degree, with δ, declination, and t as arguments. After using these tables and neglecting parallax, the numbered formulæ are used in order, and the following little table has been of service in keeping track of the signs and quadrants.

Angle	Symbol	In S. E.	In S. W.
Hour Angle	t	−	+
Altitude	h	+	+
Azimuth	A	−	+
Parallactic	q	−	+
Up to East	(z' y'')	>90° left	<90° left
Up to North	(z' x'')	<90° left	<90° right

The last two are taken as they would be before inversion by the telescope. The case of the Moon north of the prime vertical has not come up.

Following is the computation for the bird in Fig. 1. Three place logarithms with angles to the nearest degree are sufficient.

May 19, 1905. S. 21 feet east of C.

Moon's $\alpha = 17^h.0$, $\delta = -18°$

$\theta = M + 4^h.0$

$t = \theta - 17^h.0$

M	$12^h.0$	LW	4°
θ	16 .0	LS	72
t	−1 .0	B	0.24
h	30°	sin (ry)	9.986
A	−17	log d	1.322
q	−13	d sin (ry)	1.308
sin h	9.699	sin B	7.622
cos h	9.938	log r	3.686

	sin A	9.466_n	$r \sin h$ 3.385
	cos A	9.981	r 4900 ft.
	cos h sin A	9.404_n	H 2400 ft.
log	$1 - \cos^2 h \sin^2 A$	9.986	Direction N. N. E.
	sin h sin A	$9\ 165_n$	
	cos $(z'\ y'')$	9.179_n	
	$(z'\ y'')$	99°	
	cos h cos A	9.919	
log	$1 - \cos^2 h \cos^2 A$	9.748	
	sin h cos A	9.680	
	cos $(z'\ x'')$	9 932	
	$(z'\ x'')$	31°	

I have also derived a formula giving the actual direction of the flight, but it is ordinarily sufficient to estimate this from the cardinal points already drawn.

The heights of birds above the ground resulted as follows: on May 19, nine birds varied from 1200 to 2400 feet, and on October 10, the same number ranged in altitude from 1400 to 5400 feet. The greatest distance, r, of any bird from the observers, was 7100 feet for the first date and 7700 feet on the second. Most of the birds of spring were flying west of north, and those in the fall averaged southeast.

The accuracy attained in these measures depends upon the skill of the observers and the amount of the parallax. A possible error of 25% is assigned to the greatest height, 5400 feet, but the lower distances are probably correct within 10%. The accuracy of the longer measures could be increased by lengthening the base line, but there would then be no simultaneous observations of the lower birds. In fact even with a base line of ten feet we are sure that many, and probably most of the birds were too close to be seen at both stations. Often one observer would see a large bird cross the Moon's disk centrally, and the other would see nothing. Birds a mile and a half away were seen with ease, and could be observed two or three times as far off.

Previous observers have assumed that many birds flew as high as two or three miles or even more, but we have good evidence that on May 19, not one bird of the 78 was higher than half a mile, and the majority were lower than 1200 feet. On October 10, one or two birds were as high as a mile, but most of the 57 were again below 1200 or 1500 feet.

So far as we know, this is the first time this simple method has been used to determine the heights of migrating birds, and if it were practiced at many stations over the country, ornithologists would have valuable data in regard to nocturnal flight.

University of Illinois Observatory.

THE SYSTEM OF THE STARS.

W. W. PAYNE.

When Agnes Clerke published her first book in 1885, titled the "History of Astronomy during the Nineteenth Century," some astronomers felt a little anxiety, lest the attempt to write a history of Astronomy for the nineteenth century, fifteen years before the close of the period it was to cover, might fail to be a worthy supplement to the splendid work of Robert Grant who had done so well in bringing such a history from early time down to the year 1852. This anxiety was natural because the author was not known very generally at that time, and because everyone would recognize the difficulty of the task under favorable circumstances. But it was then a fortunate thing that it fell into such competent hands, and that the author was successful in producing a history that was received everywhere with marked favor. Most of our readers may already know that in 1892 the history had passed into its fourth edition and it is now a recognized authority in the fields of its research.

Late in the last-named year came another volume from the ready pen of the same writer, bearing the fascinating title of "Problems in Astrophysics." It contained 567 pages of compact information all along the border line of the modern phases of astronomical science, setting out definitely, in popular language, most of the important problems that were occupying the attention of leading astrophysicists everywhere. As every reader might expect, that volume was heartily welcomed in America, and its influence in this country was very great over the devotees of the new astronomy, for it gave the student, the physicist and the working astronomers just the information they most needed, in language equally easy for all. A single remark made to the writer by one of America's most able astronomers about this book is full of meaning in this connection. He said: "I wish I knew enough to review that book."

We have just received a copy of the second edition of "The System of the Stars." In 1890 the first edition appeared; since that time very considerable advancement has been made in the knowledge gained from the study of the stars in various ways, some of it being so fundamental in kind, as to remind us of what has happened to the best text-book in college astronomy in the English language, viz: that after ten years of recent use, it was found to be so incomplete that a revision of it was necessary, in the author's judgment. If a first-rate text-book in astronomy,

in modern times, can not last more than ten years without revision, fifteen years is indeed a long time to wait for a revision of a standard work like that of "The System of the Stars" which must be, in the nature of the theme, largely problematical in character.

It will be helpful to the interested reader to take notice of some of the more important changes that have been made in the revision as compared with the former volume. In general, it may be said, that some portions have been recast, new chapters inserted, old ones suppressed in part, and the entire work has been thoroughly revised. Most of the illustrations are new, and the printing of them is clear and exceptionally perfect. In the new volume we see, on page 5, that the topic of scintillation is improved by important additions. Respighi's study of the fluctuations of the prismatic images of the light of the stars is referred to with the needful citations for fuller reading if desired. In this connection, it is well said that his work gives the first secure basis for a scientific theory of the so-called twinkling of stars.

When speaking of the light of the stars on pages seven and eight some corrections are noticed and new matter added. Best photometric data now put the entire light of Argelander's 324,000 stars as equivalent to one four-hundred and fortieth of full moonlight, and if the light of the 900,000 stars in both hemispheres is similarly enumerated it amounts to one one-hundred and eightieth of the light of the full Moon. The total amount of light from all the stars in the Universe, which may count up to more than 100 millions, is a thing very difficult to estimate. Opinions of scholars differ on this point, Sir William Abney in 1896 claimed by photographic results that the entire starlight of both hemispheres amounted to one one-hundredth of full moonlight. Prof. Newcomb in 1901 made it equal to 728 times the light of Capella, or, one eighty-ninth of the light of the full Moon. In this connection the author makes reference to the work of Gavin J. Burns which, though not very full, led him to think that the radiance of the entire sky from starlight was a little under one per cent of the light of the full Moon. At the close of Mr. Burns' article, the remark is made that his calculation is based on the assumption, (which he believes is very doubtful) that the only source of the light of the sky is from all the stars visible and telescopic. This important suggestion must be taken into the account in measures of skylight radiance, and there are many interesting questions connected with this one still waiting for

the painstaking investigator.

Near the close of the first chapter, attention is called to late advanced work in the study of the nebulæ by the aid of large telescopes armed with suitable photographic apparatus. The credit of pioneering in this new and almost limitless field is given to Prof. Keeler who used the Crossley reflector, at Lick Observatory, so effectively as to raise the hope that 120,000 of them might be recorded on the sensitive photographic plate. For many reasons astronomers now feel that such records would be of great value to astronomy, and the sooner the first survey of this kind can be made the better.

In the second chapter treating of the methods of sidereal research, the theme of photometry is considerably changed and brought up to date both in respect to method and result. The work of the original and revised Harvard Photometry is noticed quite fully. It needs to be read for a comprehension of the splendid results that are constantly coming to the aid of the science of the stars from this prolific source. It is noteworthy that the relations of photometry and photography are becoming so interdependent, that neither is generally conclusive in its work without the aid of the other. Then, again, when the photographic plate containing possibly thousands of clean, sharp and round star dots, is in hand, the work of finding the exact places of those star images so as to have a correct relative map of them for reference, is only just begun. The work of measuring those plates by delicate machinery devised especially for the purpose is a herculean task in itself, needing the patience and skill for some of it, that is purely expert in kind and quality.

In comparing the refracting telescope and the reflecting the author, without doubt justly gives the preference to the reflector for work upon the faint spectra with the slitless spectrograph. We were surprised at the statement made on page 33, where it is said that, "Under the best conditions, no more than five per cent of the light striking the 40-inch object-glass of the Yerkes Refractor actually reaches the sensitive film after transmission through the great Bruce spectrograph; and although the waste in other forms of apparatus is less formidable in amount, they can not yield results of equal precision."

The reader will be surprised at the facts given in the above paragraph, in relation to the loss of light in the use of large and powerful instruments. The statements made by the author are conservative and trustworthy. In the Astrophysical Journal Vol. XV, pp. 19, 20, Professor Frost says:

"As has been pointed out by Professor Campbell, the actual loss of stellar light in a slit spectrograph with a train of prisms is serious in the extreme. An exact statement is not possible for lack of adequate data as to the absorption and reflections in the lenses involved. In the present case probably at least 40 per cent of the light is lost at the 40-inch objective, and further amounts at the correcting lens and collimator; the prism train transits only about 30 per cent of the beam incident upon it, and finally the camera lens exacts its tribute. Thus, a conservative estimate would assign a loss hardly less than 90 per cent of the star's light falling on the 40-inch object-glass without considering the waste of light at the slit. Under average conditions of atmospheric unsteadiness, probably less than one half of the light falling on the jaws actually enters the slit; with 'bad seeing' this becomes as low as one fifth. Hence, taking into account the inaccuracy of guiding, it would seem that with good conditions of atmosphere not over one twentieth of the star's light falling upon the object-glass is effective on the plate of the camera, and under bad conditions this may be as low as one one-hundreth."

When we come to that part of the revision which treats of the stars as Suns, the chemistry of stars, the temperature of the stars, gaseous stars and nebulæ, in chapters three to seven, we notice with interest that the subject matter is almost wholly recast, and entirely illustrated anew from some of the fine photographs recently taken by Professor Pickering of Harvard College Observatory. The full illustration here given of the various types of the stars in modern classification make the accompanying text in its full details reading that is easy and very satisfactorily definite.

In the next two themes, the temporary stars, and the variable stars of long period there are important additions of matter and new plates and cuts that add very materially to what was given in the first edition. This, also, would be expected because there is so much that is new in kind and choice in quality that it is no light task to select and arrange the new and the old in one systematic and harmonious whole; and yet any interested reader will be pleased to see for himself how well the task has been done.

Profitable references might also be made to the treatment of variable stars of short period, the colors of the stars, the double stars, stellar orbits, variable double stars, spectroscopic binaries, multiple stars, and their evolution, the Pleiades, star clusters, the forms of nebulæ, the great nebulæ, the nature and changes

of the nebulæ; but this is scarcely necessary; for enough has been said to give a fairly full idea of what has been done in this revision to bring it to date with an inclusive fullness of standard value.

The final chapters, on the distances of the stars, the translation of the solar system, the proper motions of the stars, the Milky Way, the status of the nebulæ and the construction of the heavens are intensely interesting to any reader. They deal with such great thoughts, and open such long reaches of imaginative possibility, such weird phases of probability, such certainties of beneficient power, and such matchless beauty in creative wisdom that one pauses in awe, as he wonders what the meaning of this can be, both for all changeful time and for the unchanging eternity.

This book can be secured from the Macmillan Company, the New York publishers, 66, Fifth Avenue and its cost is $6.50.

A REVISED LIST OF VARIABLE STARS OF SHORT PERIOD.

H. C. WILSON.

For Popular Astronomy.

In order to prepare the monthly ephemerides of the short period variable stars, the writer has recently found it necessary to collect the best elements of these stars from various sources, and it has been thought best to publish the revised list in Popular Astronomy. After going through the astronomical publications which were at hand at Goodsell Observatory quite thoroughly for the desired data we sent the copy to Professor E. C. Pickering, Director of the Harvard College Observatory for revision and he has very kindly made several corrections, so that we think that the list is now practically correct to the present date.

The names given to the stars are those adopted by the Variable Star Committee of the *Astronomische Gesellschaft*. The magnitudes are only approximate in many cases, being taken from various sources. The references are as follows:

A J 553 = the Astronomical Journal No. 553, containing Dr. S. C. Chandler's "Revision of Elements of Third Catalogue of Variable Stars."

A N = Astronomische Nachrichten. The number following the letters is the current number of that journal.

Ap J = The Astrophysical Journal.

B A = Bulletin Astronomique.

M N = Monthly Notices of the Royal Astronomical Society.

Revised List of Variables of the Algol Type.

Name	R. A. 1900 h m s	Decl. 1900 ° ′	Mag. max.	Mag. min.	Period d h m s	Reference	Elements (Minimum.) Julian Day	d
U Cephei	0 53 23	+81 20.2	7.1	9.2	2 11 49 44.55	AJ 553	2407890.3229	+2.492877E
Z Persei	2 33 41	+41 46 0	9.4	12	3 1 21 32.23	AN 3820	2416009.6934	+3.056623E
β Persei (Algol)	3 01 40	+40 34.2	2.3	3.5	2 20 48 55.6	AJ 553	2410640.3411	+2.867310E + 147m sin (0°.024 E + 226°) + 22m sin (0.077° E + 216°)
RT Persei	3 16 43.5	+46 12.2	9.10	11	0 20 23 11	PA 129 | AN 3970 ∫	2416741.24514	+0.84943E
λ Tauri	3 55 08	+12 12.5	3.4	4.5	3 22 52.2	AJ 553	2410612.4979	+3.952917E
RS Cephei	4 48 34	+80 05.8	9.5	12.?	12 10 04.8	∫ PA 130 | AN 4039	2410011.4	+12.42E
R Canis Maj.	7 14 56	−16 12.4	5.9	6.7	1 3 15 46.07	AJ 553	2410357.6375	+1.135948E
Y Camelopardi	7 27 39	+76 16.9	9.10	12	3 7 20.1	Eph. verand. | Sterne 1905 ∫	2416848.5167	+3.30562E
RR Puppis	7 43 31	−41 08.0	9.10	—	6 10 18 58.2	Annals Cape Obs. Vol. 9,593	2415021.85902	+6.4298E
V Puppis	7 55 22	−48 58.4	4	5	1 10 54 26.7	AJ 553	2415021.2118	+1.4544756E
X Carinæ	8 29 07	−58 53.2	7.8	8.9	0 12 59 29.9	AJ 553	2415021.1139	+0.540318E
S Cancri	8 38 14	+19 23.6	8	10	9 11 37 45	AJ 553	2403210.5853	+9.484548E
S Antliae	9 27 56	−28 11.2	6.7	7.8	0 7 46 48.233	AN 3955	2410741.5312	+0.32416936E
S Velorum	9 29 27	−44 45.9	7.8	9.10	5 22 24 21.1	AJ 553	2415021.155555	+5.9335775E
W Urs. Maj.	9 36 43	+56 24.5	8	—	0 4 0 12.8	AN 3848	2416129.1937	+0.1668198E
RR Velorum	10 17 48	+41 36.3	10.	9.10	1 20 30.2	AJ 508	2415021.6319	+1.8543055E
Z Draconis	11 40 37	+72 49.1	9-10	12-13	1 8 34 43	AN 3888	2416177.3986	+1.3574421E
δ Libræ	14 55 38	− 8 07.3	5	6.7	2 7 51 22 8	AJ 553	2403265.38715	+2.3273472E
U Coronæ	15 14 07	+32 00.8	7.8	9	3 10 51 11.7	AJ 553	2404147.3958	+3.4522187E + 80m sin [0°.06 E + 78°].
R Aræ	16 31 06	−56 47.6	6.7	8	4 10 12 07.9	AJ 553	2415025.3157	+4.4250913E
U Ophiuchi	17 11 27	+ 1 19.3	6	6.7	0 20 07.6903	AJ 553	2408279.6472	+0.8386737E − 3m.0 t² + 0m.3 t³ (where t = E/1000)
RV Ophiuchi	17 29 45.5	+ 7 18.7	9	<11		AN 3963		
Z Herculis	17 53 36	+15 08.8	6.7	8	3 23 49.545	AJ 553	2413038.4640 Second minimum 45h later.	+3.9927395E
RS Sagittarii	18 10 59	−34 08.5	6.7	7.8	2 9 58 36 0	AJ 553	2404676.6667	+2.4156945E
V Serpentis	18 11 04	−15 33.5	9.10	—	3 10 53.0	AN 3977 | PA 121 ∫	2410002.677	+3.45348E
RX Herculis	18 26 01	+12 32.2	7.8	8	0 21 20 34.5	BA June '05	2414566.5304	+0.889288E

RU Lyræ	19	09	05	+41	08.2	11	—	3	14	22	23.5	AN 3811	2415960.4949	+3.598883E
U Sagittae	19	14	25	+19	25.8	6.7	9	3	9	8	10.2	AN 3770 PA 129	2415690.269	+3.380674E
SY Cygni	19	42	44	+32	27.8	10	12	6	0		9.4	AN 3614	2415004.9708	+6.006528E
WW Cygni	20	00	36	+41	18.4	9.10	12.13	3	7		37.9	AN 3970	2416722.5264	+3.317986E
SW Cygni	20	03	50	+46	00.6	9	12	4	13	45	02	AN 3581	2411343.605	+4.5729397E
VW Cygni	20	11	21	+34	11.8	9-10	11-12	8	10		23.0	AN 3899	2416348.5986	+8.432639E
UW Cygni	20	19	36	+42	55.0	10.11	13	3	10		49.2	AN 3770	2410000.20	+3.45083E
W Delphini	20	33	07	+17	55.9	9.10	11.12	4	19		21.2	AJ 553	2413564.5708	+4.806389E
Y Cygni	20	48	04	+34	17.0	7.	8.	{Even	11	57	30.2}	Ap J XI, 175	{2410250.4686 {2410150.4175	+1.498267E +1.498068E −0.000,000,022 E²} +0·000,000,022 E²}
								{Odd	1 11	57	03.0}			
VV Cygni	21	02	20	+45	22.7	11	14	1	11	26	57.3	AN 3882	2416074.164	+1.477051E
UZ Cygni	21	55	14	+43	52.1	9	11-12	31	7	18		AN 3794	2410015.05	+31.304E

Variable Stars of Short Period not of the Algol Type.

Name	R. A. 1900 h m s	Decl. 1900 ° ′	Mag. max.	Mag. min.	Period. d h m s	Reference	Elements (Maximum) Julian Day	d
V Aurigæ	5 21 32	+42 2′.2	8.6	9.6	3 20 37	MN LXV.3	2415420.64	+ 3.8590E
T Monoc.	6 19 49	+ 7 08.4	6	8	27.0122	AJ 553	2409633.63	+27.0122E
W Gemin.	6 29 14	+15 24.5	6.7	7.5	7 21 59 5	AN 4056	2413266.35	+ 7.91603E
ζ Gemin.	6 58 11	+20 43.0	3.7	4.5	10 3 41 30	AJ 553	2410640.60	+10.15382E
V Carinæ	8 26 41	−59 47.3	7.2	8.0	6 16 41	AJ 553	2415026.78	+ 6.6951E
T Velorum	8 34 26	−47 00.7	7.5	8.5	4 15 20.4	AJ 553	2415022.78	+ 4.6392E
{=W Carinæ {=V Velorum	9 19 15	−55 32.0	7.5	8.5	4 8 54	AJ 553	2415021.64	+ 4.3709E
S Muscæ	12 07 24	−69 35.7	6.5	7.3	9 15 46	AJ 553	2415029.18	+ 9.657E
T Crucis	12 15 54	−61 43.6	6.8	7.6	6 17 34	AJ 553	2415028.32	+ 6.7322E
R Crucis	12 18 08	−61 04.5	6.8	8.0	5 19 47 47	AJ 553	2415027.39	+ 5.82485E
S Crucis	12 48 27	−57 53·3	6.6	7.8	4 16 33 27	AJ 533	2415026.92	+ 4.68989E
W Virginis	13 20 52	− 2 51.5	9.0	10.0	17 6 30.5	AJ 553	2402708.27	+17.2711E
V Centauri	14 25 23	−56 26.7	6.7	7.6	5 11 51 17	AJ 553	2415025.52	+ 5.49394E
R Triang. Austr.	15 10 49	−66 07.7	6.7	7.7	3 9 20 30	AJ 553	2404623.71	+ 3.38922E
S Triang. Austr.	15 52 12	−63 29.5	6.5	7.5	6 7 45.2	AJ 553	2415023.41	+ 6.3231E

Variable Stars of Short Period not of the Algol Type.—Continued.

Name	R. A. 1900 h m s	Decl. 1900 ° ′	Mag. max.	Mag. min.	Period d h m s	Reference	Elements (Maximum.) Julian Day	d
S Normæ	16 10 35	−57 39.2	6.5	7.4	9 18 03.6	AJ 553	2415029.45	+ 9.7525E
RV Scorpii	16 51 47	−33 27.2	6.8	7.6	6 1 29.5	AJ 553	2415026.04	+ 6.0622E
X Sagittarii	17 41 16	−27 47.6	4	6	7 0 17 4	AJ 553	2404291.78	+ 7.01185E
Y Ophiuchi	17 47 17	− 6 07.1	6.2	7.0	17 2 54.1	AJ 553	2408694.25	+17.1207E
W Sagittarii	17 58 38	−29 35.1	4.8	5.8	7 14 16.3	AJ 553	2402849.45	+ 7.5946E
Y Sagittarii	18 15 30	−18 54.3	5.8	6.6	5 18 33.7	AJ 553	2410175.10	+ 5.7734E
U Sagittarii	18 26 00	−19 11.7	7.0	8.3	6 17 52.2	AJ 553	2404245.00	+ 6.7446E
β Lyrae	18 46 23	+33 14.8	3.4	4.5	12 21 47 32	AJ 553	Min. 1855 Jan. 6.604	+12d.908009E + 3d.855 (E/1000)² − 0.047 (E/1000)³.
κ Pavonis	18 46 38	−67 21.5	4.0	5.5	9 2 27	AJ 533 See Errata	2404765.3	+ 9.0914E
U Aquilae	19 23 58	− 7 15.0	6.4	7.1	7 0 34.5	AJ 553	2410170.15	+ 7.0240E
U Vulpeculae	19 32 15	+20 06.6	6.9	7.6	7 23 31.2	Annuaire 1905	2416881.083	+ 7.979977E
SU Cygni	19 40 48	+29 01.3	6.7	7.4	3 20 18.2	AN 3843 AJ 432	2414202.66	+ 3.844E
η Aquilae	19 47 23	+ 0 44.9	3.5	4.7	7 4 13 54	AJ 553	2396168.625	+ 7.176381E
S Sagittae	19 51 29	+16 22.2	5.6	6.4	8 9 11 48	AJ 553	2406602.60	+ 8.38320 E
X Cygni	20 39 29	+35 13.6	6.4	7.7	16 9 15.1	AJ 553	2410190.90	+16.3855E
T Vulpec.	20 47 13	+27 52.5	5.5	6.5	4 10 27 31	AJ 553	2409849.01	+ 4.43578E
WZ Cygni	20 49 18	+38 27.1	9.8	10.8	0 14 01 37.7	AN 4053	Min. 2414936.5487	+ 0.584464E
TX Cygni	20 56 25	+42 12.4	8.5	9.7	14 17 25.44	AN 3769	2415673.41	+ 14.726E
VY Cygni	21 0 26	+39 34.5	8.9	9.5	7 20 34 4.8	AN 164.43	2416370.88	+ 7.857E
δ Cephei	22 25 27	+57 54.2	3.7	4.9	5 8 47 39.3	AJ 553	2393375.4514 (1840 Sept. 26, 10h 50m + 5d 8h 47m 39s.3 E − 0d.0008 E² − 0.00000015 E³)	+ 5.366427E

Ant-Algol Type Stars.

Y Lyræ	18 34 13	+43 52.2	10.11	12	0 12 03 52.74	MN LXV, 6	2415020.2745	+ 0.5026937E
RZ Lyræ	18 39 54	+32 41.8	9.9	11.2	0 12 16 15	AN 3880 AN 3898	2416266.5768	+ 0.511284E
UY Cygni	20 52 16	+30 02.6	9-10	10-11	0 13 27 25.37	MN LXV, 6	2415346.3933	+ 0.5607103E
U Pegasi	23 52 53	+15 23.9	9.0	9.7	0 4 29 50.67	AJ 553	1894 Sept. 22d 18h 13m.2 + 4h 29m 50s.67E	

P A = Popular Astronomy.

Annuaire 1905 = Annuaire pour l'an 1905, publie par le Bureau des Longitudes, Paris.

Eph. veränd. Sterne 1905 = Ephemeriden verändlicher Sterne für 1905, von E. Hartwig.

The elements given are the Julian day of some well determined minimum or maximum and the period, in days and decimals of a day, which must be multiplied by E, the number of periods which have elapsed since the given minimum or maximum, in order to predict any later similar phase of the star. In a few instances the period is itself found to be changing and this variation is taken account of by the addition of terms containing the square and the cube of E.

In the tables which are published monthly in *Popular Astronomy* the times of minima or maxima are given only to the nearest hour, for it is well that the observer should not be prejudiced by knowing, or thinking that he knows, the time too closely beforehand. We, however, compute the time to the nearest minute of Greenwich time, and any of our readers may do this themselves with the aid of the data here given.

As an example of the computation necessary for the prediction of a single minimum let us take that of U Cephei for March 18, 1906. The elements given in the list are

$$\text{Minimum} = \text{J. D. } 2407890.3229 + 2^{d}.492877\ E.$$

The Julian day given in the American Ephemeris for January 1, 1906 is 2417212. That for March 18, is 76 days greater or 2417288. Subtracting 2407890 from 2417288, we have 9398 days as the interval which has elapsed since the zero minimum adopted for the elements. The period of U Cephei, 2.492877 days, is contained in that interval approximately 3770 times. Multiplying $2^{d}.492877$ by 3770 we have $9398^{d}.1463$, which added to 2407890.3229 gives 2417288.4692. Converting the decimal of a day .4692 into hours and minutes we have as the predicted moment of a minimum March 18, $11^{h}\ 16^{m}$, Greenwich mean time. This should further be corrected for the aberration of light, i. e. the difference of the times at which the rays of light emitted by the star at the same moment reach the Sun and the Earth. This difference may amount at most to $\pm$ 8 minutes, and for a star near the pole of the ecliptic it is much smaller.

RECENT DOUBLE STAR WORK.

S. W. BURNHAM.

For Popular Astronomy.

One of the most interesting and valuable contributions to double star literature in the way of micrometrical measures has recently

been issued by the Flower Observatory of the University of Pennsylvania as Volume II of its publications under the title, "Measures of 1066 double and multiple stars made with the 18-inch refractor of the Flower Observatory, by Eric Doolittle." At no time or place has there been printed a more thorough and complete series of measures. Every pair has been fully measured on three or more nights, and under conditions suitable for accurate and accordant measures. No stars are given with a single measure, and there are no incomplete observations. Evidently the observer has adopted the wise and safe plan of leaving a pair alone when the conditions are not good enough to measure both distance and angle. The working list was made up with excellent judgment as to the needs of observation, and consequently very little of the work done will be found to be duplicated elsewhere. The writer is specially indebted to Mr. Doolittle for an advance copy of this work, and previously for many of the mean results in manuscript, for use in his General Catalogue now going through the press. These measures are very important in a large number of cases in bringing the history of the several pairs down to a very recent date.

This publication has the style and arrangement of Volume I, containing a former series of measures by the same observer, and leaves nothing to be desired on the part of those who will use it hereafter. Some of the workers in the same field on the other side of the water would present their results in a much more convenient and useful form if they would follow this model for making and recording double star observations. Many of these publications contain too much that no one wishes to have, particularly when it is mixed up and dovetailed in with the essential things in a confusing way. The material things in the order in which they should be given are; the date (expressed decimally); the position-angle; the distance; and (of stars not very well known) the magnitudes, with the mean result below. This is not only the shortest and easiest way of doing it, but much the best for the future practical use of the work. The sidereal time of the observation is of no sort of consequence; the number of settings is utterly immaterial to every one, since it is to be assumed that the skilled observer used his best judgment in this respect; weight is only a genteel way of doctoring observations which ought to be discouraged or abolished in micrometrical work. If a measure is not good enough to go in with the others on the same footing, it should be thrown out altogether. The observer passes upon this question when he commences to make a measure, and should

know whether the conditions, considering the difficulty of the object, are such as to warrant making the observation. Having done this, and made the measure, it should not be juggled with, and should be treated as any other unless there is some manifest blunder in it which would warrant its rejection altogether. So, also, as to the power or eyepiece used in the observation, except in close pairs of a very small fraction of a second in distance, it is a matter of no interest to any one else, and has not the slightest bearing, directly or indirectly, on the supposed value of the measure. The presumption always is that the observer in each case used the best magnifying power for that particular pair on that particular night. It might have been possible on the next night to add a few hundred diameters in measuring the same pair, but every practical observer knows that it would be absurd to give that measure any better standing in the series. In short, the simple and brief way of presenting only the essential facts in micrometrical work, has much to recommend it outside of the question of economy. If it should be remembered at this late day that the writer in years gone by has been guilty of some of the things he is now condemning, let it also be remembered that he finally saw the error of his ways, and duly repented.

In addition to the seven or eight thousand measures contained it this volume, Mr. Doolittle has re-measured nearly five hundred of the pairs discovered at the Dearborn Observatory by Professor Hough. These observations are reserved, until the series is completed, for publication in a later volume. As very many of these stars have not been observed since the original measures by Hough, the new positions will be of special interest in showing the present relation of the components. Necessarily many changes will be found as the result of orbital or proper motion, and such pairs will therefore be more likely to be looked after by observers in the future. When the vast amount of work with the micrometer performed by Mr. Doolittle since his connection with the Flower Observatory is taken into account, it is very little to say that his zeal, his industry and his endurance are alike remarkable. And in this connection one should not forget the superior defining power of the Brashear refractor with which all this work has been done.

Another valuable contribution in a different field is found in Aitken's catalogue of binary stars for which orbits have been computed (Lick Observatory Bulletin No. 84). These binaries are arranged in two classes; in the first, containing 53 stars, are

included all the systems where the motion has been sufficient to warrant the assumption that the elements of the orbits are fairly well known. It is of course expected that hereafter, with additional time and measures, all of the orbits will be improved, and some of them perhaps materially changed in periodic times and otherwise, but most of them are sufficiently accurate for provisional purposes. The stars are arranged in order of their periods, commencing with δ Equulei of 5.70 years, followed by κ Pegasi 11.37 years, ε Hydrae 15.70 years and β 883, 16.35 years, and ending with η Cassiopeia with 327 years, and Castor with 346 years. The elements are given from the latest or best authority, with notes of special interest to most of the stars. In the second class, containing 38 stars, are included all the other binaries for which orbits have been published, but which "are too unreliable to be of any practical value". This list includes such well known stars as Procyon, λ Cygni, Δ Aquarii, 36 Andromedae, λ Ophiuchi, 44 Bootis, δ Cygni, γ Leonis, μ Draconis, 61 Cygni, and ζ Aquarii, with computed periods running from 30 to 1500 years. These are all of no value and of no interest for the simple reason that the data used was wholly insufficient to base even guesswork upon; and as the most refined and scientific treatment of such observations cannot solve an indeterminate and unsolvable problem, or, in other words, make something out of nothing, the attempt to do so in these cases was hopeless, not to say absurd, alike from a mathematical as well as common sense point of view. For many of these stars it will require the observations for several hundred years to determine the orbits even approximately, and more than the work of this generation for some of the other stars. As a matter of fact, it is not absolutely certain in some cases that they are binary at all, since the observed changes are satisfactorily explained on the hypothesis of proper motion. Professor Aitken has been very liberal to computers in his selection of the stars to go into the first class. As he intimates in his introduction, several of them are more or less uncertain, and might well have been assigned to the other class.

Speaking of these he says,

"It is an encouraging sign of progress that fewer orbits than formerly are now computed from insufficient data. We have learned that reliable results cannot be obtained from a short observed arc. Many of Burnham's pairs for which no orbits have been computed have been systematically observed through a larger arc than about half the stars given in the second of these lists. A careful study of the stars referred to in that list con-

vinces me that many years must pass before we can gain much additional knowledge of double star orbits from observations of these systems. The close pairs discovered within the last twenty five or thirty years promise much larger and quicker returns".

It may be remarked here that one of the pairs discovered by Aitken himself has moved over a larger arc in the last five years than that described in many of the pairs for which orbits have been computed. As so far it has been well observed, a very few years will supply the data for an accurate determination of all the elements of the orbit. In the case of the old systems, which have taken perhaps seventy-five years for the same angular motion, at least another century will be needed to give the corresponding data of equal value.

It is rare that an arc of 180° is sufficient for even a rough approximation, and in some instances where the described path is 270°, and the measures of average quality and well distributed, there is absolutely nothing to fix the major axis of the apparent ellipse, and consequently every detail of the orbit must be wholly uncertain. An example of this class is found in Σ 1768, and other similar pairs are Σ 1639 and Σ 2525. In each of these systems the companion has been observed through more than 300° of position-angle, and yet the periods are as uncertain now as they were fifty years ago.

In a later communication on the subject of this list of binary stars, Professor Aitken says;

"Many of these orbits are based upon observed arcs so short, or upon data of such doubtful value, that they amount to no more than simple guesses, and are practically worthless. In fact, even by straining the definition of the term pretty badly, I was only able to say that fifty-three systems had 'fairly satisfactory' orbits. These fifty-three orbits vary widely in value; many are still very uncertain, and of only thirty, or at most thirty-five, can it be said with reasonable confidence that future observations are unlikely to make necessary any great change in the elements.

Nothing is more clearly demonstrated by the orbits hitherto published than the futility of trying to determine a good double star orbit from a short observed arc. It is seldom indeed that observations covering an arc of less than 180° will yield a reliable orbit, and it is safe to say that for most double stars an observed arc of at least three quadrants is necessary."

The collection of all these systems in one catalogue, whatever may be the real value of some of the learned and laborious computations, will serve a very useful purpose, and this use will con-

tinue without any needed revision for some years; but the time will surely come, and at no very distant date, when the brilliant discoveries of Aitken and Hussey at the Lick Observatory, will furnish scores of remarkable double and triple physical systems; and probably many times more in rapid orbital motion than are known altogether at this time.

Professor Hussey has printed the concluding catalogues of new double stars discovered by him at the Lick Observatory in 1904 and 1905 (Lick Observatory Bulletin Nos. 77 and 81). These lists contain 200 new pairs, and bring the total number of his discoveries at Mount Hamilton up to 1200. They contain a large proportion of very close and difficult pairs, many of them stars of the lower magnitudes, but close enough to lead one to expect to find hereafter a large number of interesting physical systems. In one respect several hundred of these stars belong to an unfortunate class. They are too difficult for observers with telescopes of average power. At this time there are but few observatories in the world where stars of this class can be properly measured; and at most points, away from Mount Hamilton, where large apertures are used, nights which are perfect enough for such work are comparatively rare. Hence, there is great danger of of such pairs being neglected, and doubtless Professor Hussey would find himself sorely handicapped at Ann Arbor even with the Mt. Hamilton 36-inch at his command.

In these last two lists, several of the old pairs have been again divided. The smaller component of Σ 557 he finds to be a 0″.24 pair: the principal star of Σ 739 is a close pair of the same distance; and, what is very unusual, he finds both components of Σ 2136 are close and difficult pairs with distance of 0″.27 and 1″.11. In two or three cases he has overlooked the identity of his pair with one previously known. For instance, No. 1071 was found by Frederic Bird some forty years ago; No. 1092 is Ho 16; and No. 1102 is β 137. These are trifling errors, and might well happen with any one in checking up a large number of stars. Professor Hussey has made a brilliant record in all fields of double star work, and one that will not be forgotten as time goes on. No one regrets any interruption, or the termination of such work by so skilled and experienced an observer so much as one who has for many years been trying to work along the same lines.

The annual results of double star measures made at the Greenwich Observatory in 1904 are later than usual in being printed in *Monthly Notices*. They are given in the number for November,

1905, and show great industry on the part of Messrs. Lewis, Bowyer and Furner. The list is longer than usual, and the objects for measurement well chosen. Only the mean results, with the number of nights on which the stars were observed, are given here. The details will be found in the annual volumes of the Observatory. Ordinarily the mean result is all that one cares for, and an early publication in this form answers all practical purposes. In one minor respect the work might be made more useful. Many of the stars are observed on a single night only, though sometimes by two or more observers. Some of them are found in several of the series of preceding years, and by looking them all over, a mean value of several night's measures can sometimes be made up, but it would be an improvement from every point of view to either finish each pair by several measures in the same year, or retain the single measure to be printed later with others, and then strike the star from the list until further observations are needed. Either one of these distinguished observers is sufficient to deal with any star on the working list, and therefore a better way would seem to be to divide up the list, and each observer make the necessary number of observations of each star, rather than for two or three observers to give a night to the same object. One does not like to take a mean of the work of different observers, but in some publications, not confined to the one in question, that is the only thing to do. It may be mentioned that in these measures the column of date is erroneously headed "1903". In the introduction to the paper, and as a matter of fact, the measures were made in 1904.

In this connection mention may be made of a catalogue of the spectroscopic binaries known to this time, prepared by Professors Campbell and Curtis, and printed in Lick Observatory Bulletin, No. 79. The list is complete to April 1905, and contains 140 stars, all of them of course bright naked-eye stars in the first four magnitudes. All important details as to the period, observer, references to observations, etc. are given in tabular form. The Lick Observatory heads the list in the number of discoveries, the Yerkes Observatory having the second place. The few remaining systems were found at the Harvard and Lowell Observatories, and at four of the European observatories.

The Yerkes Observatory,
Jan. 13, 1906.

AN ELEMENTARY EXPLANATION OF RECENT RESEARCHES ON ANCIENT ECLIPSES.

W. W. PAYNE.

Mr. P. H. Cowell has presented in *Monthly Notices*, and *The Observatory* during the last few months some remarkable work and results which concern the secular acceleration of the Moon's mean longitude and node. He has done this by a most thorough and painstaking study of some old eclipses. His work has even gone beyond the accepted theory of the motion of the lunar node, and now he is asking astronomers to give up the assumption that the Earth is going uniformly round the Sun, and substitute in the place of that idea, a resisted motion of the Earth.

The advantage that Mr. Cowell has had in attacking this difficult problem lies in the way he has gone at it. That has been to make the records of ancient solar eclipses give up all the evidence they have to bear on this question of secular acceleration, and to so handle that evidence mathematically that the most critical scrutiny can not gainsay the conclusions. To use Mr. Cowell's own words will make our meaning more definite. He says (p. 449, *Observatory* 1905): "The secular acceleration found from ancient solar eclipses of 2500 years ago have a weight proportional to the square 25. It is difficult to check the conclusions from modern observations which roughly speaking are confined to the centuries before and after 1800. To make the two classes of observations comparable, the precision of the modern observations would have to be greater in the proportion of 25 squared to one. This is not the case. The transits of Mercury do, however, afford evidence, though of little weight, that the Earth's motion is subject to a secular acceleration. It seems, however, that Mercury has no secular acceleration, and this is inconsistent with the only physical cause I can at present suggest, the resistance of the æther."

In a brief paper by Mr. Cowell in the supplementary number of the *Monthly Notices* for 1905, the same point is make in reply to arguments by Professor Newcomb against the corrections to the three lunar elements, viz: the mean longitude, the longitude of the perigee and node, based by Oppolzer and Ginzel on ancient solar eclipses. These corrections Professor Newcomb claims are incompatible with modern observations and with theory. Professor Newcomb further said in *Ast. Nach.* No 3682, that "no attempt should be made to determine the motion either of the

perigee or node from ancient eclipses," for their centesimal motions have been settled by the accordance of modern observation with theory to within limits of error that would have no "appreciable effect on the paths of ancient eclipses."

To this position Mr. Cowell replies by saying, "Professor Newcomb, however, ignores the possibility of errors in the secular variations. Now these secular variations can not be determined within 5″ by modern observations, and the theory certainly is not above suspicion. No theoretical values have to my knowledge been published since Hansen's, who in the case of the mean longitude gave the erroneous value of 12.

Now any error in the assumed value of g the mean anomaly, introduces into the Moon's tabular longitude an error $1/9 \cos g$ times the same amount. Probably, therefore, the secular term in the position of the perigee can not be determined from ancient eclipses with an accuracy much superior to that resulting from modern observations.

Hansen's secular term in the longitude of the node, however, I believe to be erroneous by over 4″, corresponding to an error of nearly one degree in the earliest eclipses. Modern observations can not criticise this correction, the objection to it is wholly theoretical."

This full quotation is made to bring out clearly the real point at issue. It is presumed that many of our readers, interested in the theoretical side of astronomy, will note with interest how the tests of observation are made a criterion, when properly applied, that should not fail to support or overthrow theory; but when not rightly applied their direct testimony is worthless.

In the same paper above referred to, Professor Newcomb raises the question: "To what extent, if at all, are we justified in determining the secular acceleration of the Moon from the supposed solar eclipses recorded by ancient historians?"

Astronomers in this country and elsewhere I suppose have long regarded this as a very important question, and they have been generally agreed that little confidence, if any, could be placed in the ancient historical accounts of early solar eclipses. So when this view was seriously questioned by Mr. Cowell, close attention has again lately been drawn to it. We give his statement quite fully in regard to this phase of early solar eclipses:

"When we examine Professor Newcomb's distrust of ancient solar eclipses, we find it is mainly, if not entirely, due to the fact that the eclipse of Xerxes, in the spring of the year of Salamis, can not be identified at all, and that in the eclipse of Thales (—584)

modern values of the secular acceleration make the central line end to the west of Asia Minor. Hence Professor Newcomb concludes that the ancient eclipses, purporting to be total, can not be safely assumed to have been so. I submit that the true inference is that ancient eclipses, when described by Herodotus or other historians born, as in the case of the eclipse of Thales, a hundred years after the event described, may be rejected. Herodotus's reputation for accuracy, is, I believe, confined to the description of events and customs that he himself saw. 'Apud Herodotum' says Cicero 'Sunt innumerabiles fabulæ.' But the inaccuracies of Herodotus are no ground for rejecting an eclipse described by Thucydides who expressly tells us that he noted down events at the time they occurred. Again, in the case of the inscriptions at Babylon and Nineveh, it seems probable that total eclipses alone would be recorded. Partial eclipses are not particularly rare or impressive phenomena, and in the case of the eclipse of—1062, the words "fire in the midst of heaven" seem conclusive. The poet Archilocus, too, may be credited with having described what he saw. Again as Tertullian considered the eclipse he refers to supernatural, it may be inferred that he would have supposed its theological significance reduced almost to zero if it had fallen far short of totality."

"The evidence that I have made use of is, therefore, I believe, in every case the evidence of eye-witnesses; but the *a priori* arguments I consider to be overshadowed completely by the *a posteriori* ones. For I have found that the same two corrections satisfy the equations of condition for five eclipses, and that one of these corrections is further supported by Mr. Nevill's amendment (*Monthly Notices* Vol. 39) to Professor Newcomb's discussion of ancient lunar eclipses. If the eclipses were total, the numerical values of my corrections are correct; if the eclipses were partial, then the amazing accident must have occurred that all five are such that they can be rendered tabularly total by the same alterations of the tables."

Mr Cowell further pursued this theme under the title "On the secular acceleration of Earth's orbital motion" in the 1905 Nov. number of *Monthly Notices*. In this article he examined the transits of *Mercury* with a view of ascertaining whether the secular acceleration of the Earth is supported by them.

The results are:

Secular acceleration of Mereury 0″.0
" " " Earth 3″.0

Thus it appears, by two different ways of finding the secular

acceleration of the earth that the results agree very closely. There still remains the surprise that the acceleration for Mercury comes out zero, especially so because we should expect a similar result for that planet if the resistance of ether is the real cause.

This recent work of Mr. Cowell has found its way into other English scientific journals, plainly showing the very general interest that has been taken in it.

In making a summary of this important work, it may be said that the Moon's longitude contains about 150 equations and its latitude about 100 equations of correction that are more than 0″.1 in value. All these 250 equations, usually spoken of as inequalities, "and the mean longitude of the Moon, require a knowledge of three angles connected with the Moon," which are the Moon's mean longitude, the mean longitude of perigee and the mean longitude of the node. The other angles involved in the arguments relate "to the position of the Sun, the planets, the solar perigee, &c., and their values are determined from other observations than those of the Moon."

The problem that Mr. Cowell had set for himself was to determine the values of the three angles named above, as functions of time, and to give a list of these 250 inequalities as accurately as possible. Speaking of the history of the lunar theory Mr. Cowell (in *Nature* Nov. 23, 1905) says:

"Before the time of Newton, this was clearly the one way the problem of the Moon's motion could be attacked, only the limit worked to was then more nearly 500″ than 0″.1. Since the time of Newton the method has been almost entirely abandoned. Many mathematicians have attempted to calculate how the Moon ought to move; the comparison between its observed and theoretical course has been rough in the extreme. No attempt has been made to verify from observation the coëfficients of these inequalities for which a theoretical value had been calculated; observation has merely been required to furnish values for those constants which are theoretically arbitrary, and as I shall show, the determination of these constants has often been rendered less accurate than was necessary by the tacit assumption that all theoretical terms had been accurately computed."

Mr. Cowell then applies this method of the study of the motion of the Moon to the time before Newton, when observations were possible only by the records of eclipses.

He then mentions the two principal inequalities of the Moon's longitude, and illustrates from simple equations, how evection and the eccentricity of the Moon's orbit could not have been ob-

tained. The importance of an extended series of observations is then noticed, and it is shown how obscure errors may run through the whole series unsuspected harm to the results as they are usually obtained and even tested for accuracy by generally approved modern methods. In the early days the elliptic inequality and convection could not be distinguished; just so now, if observation is the only test and their distribution is not made uniformly around the month certain inequalities can not be separated and certainly distinguished. If some of the terms in the fundamental equations are wrong in theory, of course some observations will show errors; while others at principal points in the lunar orbit will be without sensible error. It is in this phase of the theory of the lunar motion that Mr. Cowell has been doing some severely critical investigation, and apparently he has achieved remarkable success.

If it is possible to secure it directly from Mr. Cowell, for this publication, we wish to get for our readers a graphical illustration of his studies on this subject, that amateurs in astronomy may be helped to understand the work more easily and thoroughly.

SOLAR SPOTS AND THEIR THEORIES.

W. T. LYNN, B. A., F. R. A. S.

The earliest authentic account of the observation of a solar spot and its exact date would seem to be of that stated by several historians to have been noticed in the reign of Charlemagne, A. D. 807, on the 16th day before the calends of April, *i. e.*, on the 17th of March. This was supposed to be the planet Mercury, and Kepler, who, in his "Phenomenon Singulare seu Mercurius in Sole," claims to have witnessed a similar appearance at Prague in 1607, argues that this is a correct interpretation of the phenomenon, but contends that the true year is 1608, when, according to his calculations, the Sun and Mercury would have been in conjunction on that date. The historians, indeed, state this was seen during several days. Of course, it did not escape Kepler that Mercury could have been on the Sun's disc for only a few hours, but he suggests that the authority was really ultimately one (who, he thinks, would have possessed sufficient astronomical knowledge to know that the planet was at the time on or near the Sun and look for it there), and that he wrote *octoties*, a rather barbarous form of *octies*, meaning that it was seen eight times,

and that this word was mistaken by others for *octo dies*. According to his account, he saw the planet himself in a similar position on the 28th of May (New Style) 1607. He observed it on a screen on which the Sun's image was received after passing through a small hole in a shutter, when the spot (Mercury, as he supposed) was seen of the size of a small fly, diffused in appearance like a little cloud, on the left-hand side and in the lower part of the image. He called the attention of Dr. Martin Bachazek, then rector of the Prague Academy, to it. The latter described the spot as of great blackness towards the center, more diffused and less defined towards the margin, in size and appearance resembling a thin flea. Kepler had also asked Matthias Seiffard, an old pupil of Tycho, to watch the Sun with the eye when possible during four days, and on this day, after his own observation, he asked whether he had noticed anything unusual. At first he replied nothing that he could be certain of but, when pressed, he said that he had had glimpses of an object on the disc which appeared to change its place, but in which direction it was moving he seemed to be in doubt, but thought it was towards the right, whereas Kepler's own impression was that it was towards the left. Of course, a spot would move to the naked eye towards the right.

This observation is of rather special interest as being the first undoubted observation of a solar spot in motion only two years before the application of the telescope to the heavenly bodies made these observations of frequent occurrence. It is perhaps noteworthy that the observation in the reign of Charlemagne was almost exactly 200 years before that of Kepler, and a period of 200 years is just equal to 18 periods of solar spots. It seems probable that on both occasions the event was a year or so after a maximum, but large spots do often so occur, as we have had experience in the present year.

Perhaps I may be allowed to add a few remarks respecting the history of the older theories of solar spots, on which subject I have received an interesting paper from Professor Lebon, of the Lycée Charlemagne. The idea of Scheiner that they were small planets or bodies passing in front of the Sun was soon given up, not only on account of their appearance, so different from that of solid bodies, but because they move in the reverse direction to that which bodies would have in circulating round the Sun. That of Galileo, that they were clouds, has been held by some even to our own time. M. Lebon points out that the volcanic theory of the spots, attributed by many to Cassini I., and by Lalande to

our countryman Derham (although Derham himself attributed it to Crabtree in a letter which, though written in 1640, remained unedited till 1711), was really first put forth by Willebrord Snell (the discoverer of the law of refraction) in 1619 in his "Descriptio Cometæ qui anno 1618 mense Novembri primum effulsit." M. Lebon calls attention to the fact (also generally overlooked) that the spots are of the nature of foam or spray was first stated by Descartes in the third part of his "Principia Philosophiæ," published in 1644. What may be called the Scoriæ theory is rightly assigned by Lalande to La Hire, but was suggested by the latter in 1686, not in 1700 or 1702, as Lalande dates it, for the later view scarcely modifies the earlier. Finally, M. Lebon speaks of rock theory. It is remarkable that Lalande seems to have thought himself the originator of this in his "Astronomie," and speaks of it as "mon hypothèse" in one of his "Mémoires sur les Taches du Soleil et sur sa rotation," which was published in 1775. Yet it was publicly taught in his lectures by Delisle in 1719, as is shown by a manuscript recently discovered and presented to the Paris Observatory by M. Lebon; and not only so, but is described by Cassini II, in his "Eléments d'Astronomie," published in 1740. Delambre, in his "Histoirie de l'Astronomie moderne" (1821), pointed out that Lalande's claim to priority in this matter was unfounded, but attributes it to Cassini I., on the testimony of some remarks by Cassini IV., written in 1810, and referring to a document stated to have been put forth by Cassini I. in 1671, but which Delambre was unable to find. M. Lebon has hit upon some manuscripts of Cassini II. which have convinced him that Cassini I. was indeed favorable to this theory, but that he was not the originator of it he has proved by quoting a passage from Caramuel (*i.e.*, Juan Lobkowitz Caramuel, a Spanish ecclesiastic, who died Bishop of Vigevano in Lombardy in 1682), who speaks of it in his "Mathesis nova" (1670) as held by "alii." Who these "alii" were, M. Lebon, after a laborious search, has not been able to find out, but the expression proves that the hypothesis was suggested before the time of Cassini I.

The interesting memoir of which I have been speaking, which is entitled "Pour l'histoire des Hypothèses sur la nature des Taches du Soleil," which was laid before the International Congress of Philosophy at Geneva in September last year, does not include any reference to Wilson and the latter history of solar spots. The Wilson phenomenon (which was supposed to prove that the solar spots are situated, in the vast majority of cases,

below the level of the surface of the photosphere, has been vigorously attacked in our own time by the Rev. F. Howlett, a most assiduous and careful observer for more than 30 years of the solar spots, and is now generally discredited. But much more remains to be learned; the study of the spots has become a part of the whole subject of solar research, and active efforts for combined action to throw further light upon this have been commenced this year, and will doubtless produce good fruit.

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Dec. 20, 1905.

A NOTE ON DIFFRACTION GRATING REPLICAS.*

THOS. THORP.

About the year 1898 I became possessed of a "Rowland" diffraction grating of 14,438 lines to the inch, which I fitted up for solar prominence observation and other work. During some experiments with the grating it occurred to me that possibly transparent copies might be made if only a suitable medium could be found, and with this object in view I made a number of experiments with collodion, etc., and a variety of mounting media, after first ascertaining thar no harm would come to the grating. I eventually adopted a clarified solution of celluloid in amyl acetate and nothing but pure water as a mounting medium and with the exception of certain minor details have seen no reason to alter my method, which is briefly as follows:—

Ten grammes of the clearest celluloid, shredded, are added to 700 per cent of amyl acetate, and when quite dissolved the whole is slowly filtered through cotton tow, when a very clear solution is obtained. About 2 per cent. of this solution is poured on the surface of the grating, which is some 2.5 in. in diameter (after the same has been very carefully levelled) and then allowed to dry. Special precautions must of course be taken to prevent access of dust, as far as possible, and to secure uniform drying, as upon this latter depends the optical perfection of the film; its thickness is about 1-6000 of an inch. The surface of the glass upon which the film is to be mounted is now cleaned and left standing with water upon it. The film, which by the way takes about a day to dry, is now moistened, and, in a very short time, being found to be easily detachable, is stripped and placed face downward upon the wet surface of the glass. After getting

* *The British Journal of Photography.* December 29, 1905.

rid of the bulk of the water by tilting, the film is generally allowed to dry spontaneously, but I often hasten the process by using blotting paper of a particularly smooth kind, and in this way the drying is only a question of a few minutes. The edges of the grating are now pared round and fastened down by means of the same solution, a camel-hair brush being used for this purpose. Before this latter operation, however, the gratings are tested in the spectroscope, and if found optically good are placed face down upon the original grating or on a similar grating. Now, as celluloid shrinks in drying and not always to the same extent, due to slight differences in temperatures and quantities of solution, the lines are somewhat closer on the replica than on the original, and a little consideration will show that the interference bands produced by contact of the two surfaces are a measure of the shrinkage, and all one has to do is to add to the original number of lines to the inch to that of the interference lines to get the correct spacing in the replica. The shrinkage varies from about 50 to 100 to the inch.

Whilst the film is still on the grating it is my usual custom to place it behind a sodium flame, when the condition of the surface shows at once whether the drying has been uniform or not. Several rings appear at times approaching the center, and the replica is then known to be worthless as the shrinkage will not be uniform when mounted.

It may appear at first sight that this method of mounting is only a very temporary one; and so it is in a sense, as the films can be taken up and remounted with ease, but really after a time the films become adherent indeed, and great difficulty is experienced in removing old films except by dissolving.

In my original experiments the method of mounting the film with the grating side to the glass was tried in the way now used, I believe, by Mr. Ives (without, however, any backing), but the results were not satisfactory, as interference due to the film took place, and the definition was not improved in any way.

I may here say that I have brought the particulars above described before the Manchester Literary and Philosophical Society from time to time as may be seen by looking up the memoirs and proceedings.

In the year 1900 I applied these grating replicas to color photography and read a paper on the subject before the above society, and in a patent I took out for the combination a claim is also made for a method of producing grating replicas by first giving the grating a coating of oil, and in Mr. Wallace's article

in the "Astrophysical Journal" for September he takes it that this is the method I have all along adopted for ordinary replicas. Such, however, is not the case, the method being as given in the foregoing particulars. Of course, considerable attention has to be paid to every part of the process, and it is only by large experience that one can produce grating replicas which are optically useful.

As stated in my latter in the current number of "Nature," I have also succeeded in making replicas of a concave grating kindly lent to me by Professor Schuster and in mounting the same on a concave surface, but as all wet methods of silvering I have tried have the effect of producing a large amount of scattered light their further production has been left over for the present.

I have mounted many of the plane films on concave surfaces, and it is found that fair definition can be obtained by them, although it is well known that the distortion prevents high-class work being attempted.

Curiously enough, although these unsilvered replicas reflect visible light very slightly, ultra-violet light to at least λ 1852 can easily be made out. This discovery was made by Mr. Morris Airey, of the Victoria University.

The two grating replicas and two prism-gratings I send herewith are from originals of 14,438 and 15,028 lines to the inch respectively, and may be taken as good examples of my method of reproduction, the few small specks on the surface being due to dust particles and not to the method of mounting. A very cursory examination will show a considerable difference between the gratings, the one concentrating the greatest amount of light into the first spectrum on one side being taken from an original at one time the property of the late Dr. Common, whilst the other is from a particularly fine specimen of recent work on the Rowland engine. The same may be said of the prism-gratings.

In the latter case, however, it will be seen that by suitably tilting the prism the d.v. spectrum increases largely in brightness as well as dispersion, and owing to the absence of scattered light this form will probably be found the best for photographic purposes, as it certainly has been for solar prominence work, one of these prism-gratings giving a dispersion equal to five flint glass prisms in the middle of the spectrum and of course more at the red end.

I may just mention here that Sir William Abney also possesses a much larger grating than I use which has almost the same characteristics as that I purchased from the late Dr. Common, and that he has been kind enough to allow me to make replicas

from it on two separate occasions.

Finally, whilst admiring and welcoming the methods adopted by Mr. Wallace and others in the production of grating replicas, I have written the above with a view to substantiate my own claim to the first method of producing optically useful replicas of gratings and one which after all has not in my opinion been superseded.

THE DUAL OBSERVATORY.

JOHN D. PARKER.

FOR POPULAR ASTRONOMY.

The observatory is of comparatively recent origin. Until about 300 B. C., historians say that there was no real observatory. The first observatory was built at Alexandria and continued to be in active operation until the latter part of the second century of the Christian Era.

At that observatory, Hipparchus, the founder of modern astronomy, did his work. Hipparchus was very successful in his observations of the Sun, Moon and stars. He discovered the eccentricity of the Earth's orbit; he determined the obliquity of the ecliptic; he made a Catalogue containing 1080 stars, the appearance of a new star having led him to perform this work; he invented the planisphere; he was the first mathematician to demonstrate the method of calculating triangles; and to Hipparchus we also owe the method of fixing the position of places on the earth by celestial observations.

Claudius Ptolemy, who succeeded Hipparchus, made some corrections in the work of his predecessor, but himself fell into some mistakes. He was the author of the Ptolemaic System, which supposes the earth to be at the center of the Solar System, and that all the stars and Sun and planets revolve about it.

Since these early days there have been many eminent astronomers in various lands. It is impossible, in a brief article, even to mention their names. We can note only such eminent ones as Copernicus, Tycho Brahe, Kepler, Galileo, Huyghens, Cassini, LaPlace, Sir Isaac Newton and the Herschels.

There has been a great improvement in astronomical instruments and in the form of observatories in modern times. The greatest improvement, perhaps, has been in the telescope. The old reflecting telescope has given place largely to the modern refractor. The great reflector of Sir William Herschel has been dismounted, and gone into disuse. The reflector is now only a cur-

iosity. Many astronomers resort to the place to see it and to read the mural tablet which says that Sir William Herschel "Burst the Barrier of Heaven."

Astronomy has made great advances in modern times but it is evident that there is still a defect in the construction of the observatory. The plan of the building needs to be changed before we can reap the full benefit of the work of modern astronomers.

The great need of modern observers is the dual observatory. Hitherto all observations have been of celestial objects. Astronomers have found out that the earth plays an important part in observations. Meteorology and magnetism are both very important. We need observatories for such work, and also instruments. This work has been done by astronomers hitherto, but they are handicapped in it. The work differs so much in kind that other men ought to do it. To be really successful a man ought to give his whole time and strength to one kind of work. No man can be an astronomer in the usual acceptation of the term, if his attention is divided.

The true plan is to separate these two observatories, and to relegate what we call astronomy to those who devote their whole time to celestial observations. The work of studying the forces that belong to the earth should be given to those who make a special study of those things, meteorology and magnetism being sufficient to absorb all the time and powers of a man.

In this way we must have dual observatories for celestial and for terrestrial observations. The two kinds of work can not be done so well by the same men. The best site for an observatory of this kind is San Miguel. This beautiful sugar-loaf mountain lies about sixteen miles east of San Diego, California. The summit of the mountain is divided into two peaks, one of which could be utilized for a celestial observatory, and the other for a terrestrial. It is indeed an ideal location for a dual observatory. There is less fog at San Diego than at any other place on the coast north of it. There is very little cloudy weather there. Observations at San Diego can probably be carried on about three hundred nights in each year. There is also a land breeze which keeps the atmosphere clear at night, no matter how large the city grows.

THE JULIAN PERIOD.

R. W. McFARLAND.

For Popular Astronomy.

This is a system of chronology. It was invented, as lately stated in this journal, by Joseph Scaliger in the latter part of the sixteenth century. It was offered as a plan which men of all nations might use, if not for the ordinary events of daily life, at least for the most notable events of human action or human thought.

In the fourth edition of Herschel's Outlines of Astronomy, there is a table of about thirty events, historical or mythical, real or imaginary, as the case may be, many of which have been before the learned world for centuries, and have been considered as established points of reference. The year of the Julian Period and also the day are given in every instance. For example, the last day of Old Style in England, was September 2, 1752. It is given as being in the year 6465, and the 2,361,221st day of the Period. As before stated, it is the custom of the American Nautical Almanac to give each year the day of the Julian Period which the first of January indicates.

The cycle is a term of 7980 years, being the continued product of 28, 19, and 15, the years for the Solar cycle, the Lunar cycle or Golden Number, and the Roman Indiction respectively. It will be remembered that the Lunar cycle was in use more than four centuries before the beginning of the Christian Era, and the other two are traceable to the early part of that era. Almanacs always give the number of the cycle. In 1906 the Solar cycle is 11, the Golden Number 7, the Indiction 4.

Herschel's unexplained rule for finding the year when these three quantities are given, is as follows: Multiply the number of the Solar cycle by 4845, the Golden Number by 4200, and the Indiction by 6916, add the products and divide the sum by 7980, the remainder is the year of the Julian Period. From this remainder subtract 4713 and this new remainder will be the year of the Christian Era. Try this with the numbers given above, and the rule is at once seen to be correct.

But how is the rule made? That will be given further on. Works on astronomy also say that to find the Golden Number for any given year, add 1 to the year and divide the sum by 19, the remainder is the Golden Number for that year. For the Solar cycle, add 9 to the year, and divide by 28, the remainder is the

Solar cycle. For the Indiction, add 3 and divide by 15, the remainder is the Indiction. How is this known? The reason will be shown further on.

The answer to these questions is found by Indeterminate Analysis, a branch or section of algebra much more in practical use fifty years ago than it is at present. It will be noticed that in the cases given above, no attention is paid to the quotients—the remainder is the object sought. If there are two unknown quantities and only one equation, or three unknown quantities and two equations, how can we find a series of numbers which will fulfill the conditions? It is done by the aforesaid Analysis.

For example, what is the smallest number and what is the series of numbers, if any, which being divided by 7 will leave 2 as the remainder, but being divided by 8 will leave 3? The answer is 51, the smallest number, the series being 51, 107,163, 216, etc. Found as follows: Let x be any one of such a set of numbers, then if we subtract 2 before dividing by 7, there will be no remainder, and similarly, if we subtract 3 before dividing by 8, i. e., $\frac{x-2}{7}$ and $\frac{x-3}{8}$ will both be integers, that is, whole numbers, —not fractions.

Algebraically we have $\frac{x-2}{7}$ = a whole number, say p. $\frac{x-2}{7} = p$, hence $x = 7p + 2$, (A). Put this value of x in the other term, then we have $\frac{7p+2-3}{8}$ = some integer. But if we put this equal to some letter, and find the value of p, it will be in the form of a fraction having 7 as the denominator, and the quotient will not necessarily be an integer. But the conditions of the question require only integers. If an integer is multiplied by an integer, the product is also an integer, and if an integer be subtracted from an integer the remainder is an integer. The above expression simplified, becomes $\frac{7p-1}{8}$. Now $\frac{8p}{8}$ is an integer. From this subtract the preceding expression, and we have $\frac{p+1}{8}$ which also must be an integer. Put it equal to m, then $\frac{p+1}{8} = m$, or $p = 8m - 1$. Put this value of p in (A), and we have $x = 7(8m-1) + 2 = 56m - 5$. Make m equal to one, then x is 51, make x 2, 3, 4, etc., and we have the series, 107, 163, 219, etc. All these numbers fulfill the conditions of the

question, but no intermediate numbers will, as can be seen on trial.

The beginning of the Julian Period was assumed to be the year in which each of the three cycles was represented by the number 1. All three would continue to be represented by a single number till the sixteenth year. In this year the Indiction having finished one period would begin with one again, while the other two would each be 16. The 25th year would find the Indiction 10, the Golden Number 6, and the Solar cycle 25. In this way you will pass over 7980 years before all the three cycles will again be represented by one, and any one combination of the numbers representing the three cycles will occur once and only once in that long series of years.

The year 1906 has the Indiction 4, the Golden Number 7, and the Solar cycle 11. From these find the year of the Julian Period and the answer to the other questions.

Let x be the year of the Julian Period, then by the principles previously given

$\frac{x-4}{15}$, $\frac{x-7}{19}$, and $\frac{x-11}{28}$ will all be integers.

Put $\frac{x-4}{15} = p$, then $x = 15\,p + 4$ (B). Put this value of x in the second expression, and we have $\frac{15\,p+4-7}{19}$ equal to some whole number. If this is put equal to some letter, as m, and the value of p be found, the denominator would be 15, and the value of p would not necessarily be integral. Simplify the expression and after multiplying by 5, we find $\frac{75\,p-15}{19}$ which must be an integer. Divide by 19, the remainder is $\frac{18p-15}{19}$. Subtract this from $\frac{19\,p}{19}$, the remainder is $\frac{p+15}{19}$. Put this equal to m, then $\frac{p+15}{19} = m$, and $p = 19\,m - 15$. Put this value of p in (B), then $x = 15\,(19\,m - 15) + 4 = 285\,m - 221$ (C). Put this value of x in the third expression $\frac{x-11}{28}$ and we will get $\frac{285\,m-232}{28}$ and this also must be an integer. Dividing by 28, we find the remainder is $\frac{5\,m-8}{28}$. To make the co-efficient of m unity, multiply by 11, on dividing by 28 we have the remainder

$\frac{27\,m-4}{28}$. Subtract this from $\frac{28\,m}{28}$, the remainder is $\frac{m+4}{28}$, which must be an integer. Put it to equal t; we have $\frac{m+4}{28}=t$, or $m = 28\,t-4$; put this in (C), and $x = 285\,(28\,t-4) - 221 = 7980\,t - 1361$. Make t equal 1, and the result is $x = 6619$, the year of the Julian Period. Inasmuch as we began with this year, 1906, subtract it from 6619, we find 4713 as the number of years elapsed at the beginning of the Christian Era. Divide 4713 by 15, the remainder is 3 which is the Indiction for the year preceding the year 1 of the Christian Era. Dividing 4713 by 19 the remainder is 1, and dividing by 28 the remainder is 9; wherefore 1 is the Golden Number, and 9 is the Solar cycle for the aforesaid year. And this shows why these numbers are to be added to any year of the Era in order to find the respective numbers for the Indiction, Golden Number, and the Solar cycle, as mentioned near the beginning of this article.

To find Herschel's rule, copied from Hutton, it is necessary to generalize the above process to find the year of the Julian Period. Let a represent the year of the Solar cycle, b that of the Lunar Cycle and c that of the Indiction. Then if x is the year of the Julian Period, the three expressions, $\frac{x-a}{28}$ (A), $\frac{x-b}{19}$ (B) and $\frac{x-c}{15}$ (C) will be integers. Put the first equal to p, and the resulting value of $x = 28\,p + a$, (D). Put this value of x in (B); we have $\frac{28\,p+a-b}{19}$; dividing by 19, the remainder is $\frac{9p+a-b}{19}$. In order to reduce the co-efficient of p to unity, multiply this fraction by 2, and subtract the result from $\frac{19\,p}{19}$. The result is $\frac{p-2\,a+2\,b}{19}$ which must be an integer. Put it equal to m, and find the value of $p = 19\,m + 2\,a - 2\,b$. Put this value of p in (D) then $x = 28\,(19\,m + 2\,a - 2\,b) + a$, that is $x = 532\,m + 57\,a - 56\,b$ (E); put this value of x in (C) and we have $\frac{532\,m+57\,a-56\,b-c}{15}$. This must be an integer. Dividing by 15 the remainder is $\frac{7\,m+12\,a-11\,b-c}{15}$. In order to make the co-efficient of m unity, double this quantity and subtract the product from $\frac{15\,m}{15}$. The double is $\frac{14\,m+24\,a-22\,b-2c}{15}$

and before subtracting, divide the numerator by 15, so as to get the smallest result possible. This gives for the numerator $14\,m + 9\,a - 7\,b - 2\,c$, and the remainder is $\frac{m-9a+7b+2c}{15}$. Put this equal to t, then we find $m = 15\,t + 9\,a - 7\,b - 2\,c$. Put this value of m in (E) and $x = 532\,(15\,t + 9\,a - 7\,b - 2\,c) + 57\,a - 56\,b$. Reducing we have $x = 7980\,t + 4845\,a - 3780$ b $- 1064\,c$, (F).

The three quantities (A), (B), and (C) were taken in that order in producing the above result. But they may be taken in different orders, and different results will be found. Had they been taken in the order (B), (A), and (C) the result would be exactly as shown in (F), but if they are taken in the order (A), (C), and (B) or (C), (A), and (B), the result is different from (F) in each case, being:

$$x = 7980\,t - 3135\,a + 4200\,b + 6916\,c\ (G).$$

Taken in the order (B), (C), and (A), or (C), (B), and (A), the results is different from (F), and is the following.

$$x = 7980\,t - 3135\,a - 3780\,b + 6916\,c\ (H)$$

The three quantities (A), (B), and (C) can be combined in only six ways, all of which are given above, and the result is three and only three different forms of the value of x. But as only the remainder is sought after division by 7980, it is easily shown that the expression (F), (G), and (H) can all be reduced to a single form, viz., the one from which Herschel's rule was formed. It is done by using this principle, that a dividend may be increased or diminished by any multiple of the divisor, without affecting such remainder. For example, use 66 for dividend and 7 for divisor, the remainder is 3. Add or subtract any multiple of 7, as 28, we have 94 and 38, divided by 7 the remainder in each case is 3, the same as before. To (F) add $7980\,b + 7980\,c$; to (G) add 7980 a; to (H) add $7980\,a + 7980\,b$, and the result is the same for all three, viz.:

$$7980\,t + 4845\,a + 4200\,b + 6916\,c\ (K).$$

If (F), (G), or (H) should be used, it would be necessary to retain the first term, $7980\,t$, lest the negative terms might exceed the positive. In (K) make $t = 0$, then the other terms put in words constitute the rule for finding the dividend, as given by Herschel, and these three terms are all that the case requires in general.

THE OCCULTATION OF ALDEBARAN. *

The occultation of the bright star Aldebaran is always an interesting phenomenon for any observer. The one to take place on March 2, 1906 may be observed so generally, if clear skies prevail, that it seems important enough to give it extended notice at this time. We are sure that amateur observers will not lose this opportunity to make as careful observations of the times of immersion and emersion as possible. The accompanying map, which was prepared by H. J. Wessling, S. J., of Woodstock College, Woodstock, Md., explains itself; it will be an aid to observers in indicating the times when these occurrences will take place. The map is sufficiently definite and clear in construction to make it quite convenient for previous notice, (whenever that may be important) so that observers need not spend time unnecessarily in case the sky should be partly clouded. The times of the phases, as laid down on the map are probably accurate within about one minute either way. The times are given in central standard time. Observers in other belts will need to notice this fact and make the necessary reduction for their respective locations. At the time of this occultation the Moon will be within a few hours of the first quarter.

Attention of amateurs is also called to the star Aldebaran on its own account. Its name is Arabic and means "the hindermost". The thought of early observers seems to have been that Aldebaran was the driver of the Pleiades.

Those using small telescopes up to four inches of clear aperture will look for the minute companion, probably of the eleventh magnitude as astronomers make it a good light test for instruments under that size. It has been seen with an objective of three and seven-tenths inches when close attention was given in the observation. Another observer has seen it with an object glass under three inches of clear aperture. It is within 2″ of arc in distance from Aldebaran. Mr. Burnham of Yerkes Observatory has noticed another attendant thirty-one and four-tenths seconds of arc distant which probably does not belong to the Aldebaran system as the latter seems to be departing from the former. Some writers, however, do not accept this view.

The occultations of Aldebaran are not infrequent as that star lies in the Moon's way and such observations are useful in determining the exact right ascension of the Moon, at some special

* See Frontispiece.

time, to test the lunar tables and the so-called Lunar Theory.

It is reported by some observers at the time of the occultation of Adelbaran that they see what they call a "singular optical illusion of *projection*". So far as we know this phenomenon is exceptional and not probably well attested. If the companion were larger, sometimes, we might expect Aldebaran to hang on the Moon's limb for an instant instead of being blotted out instantly when the Moon reaches it. Double stars sometimes behave that way when occulted by the Moon. EDITOR.

THE ASTRONOMICAL SOCIETY OF THE ATLANTIC AT THE CAPE. *

The Members of the Society started for South Africa with the purpose of attending the Meeting of the British Association, but they have not yet arrived, at least in these pages. The fact is that they went a week ahead of the main party, and found so much to do in that extra week that their chronicler must beg one more indulgence from the Editors of this Journal, ere he cuts the talk and comes to the—"British Asses."

There is a peculiarity about lunch at the Royal Observatory at the Cape. It gets lost in a cloud of smoke and suddenly it is tea-time; at any rate, that is what happens when the plans of the Senior Member from Groningen are exposed to the fierce light of practical experience that shines under one corner of Table Mountain. One of the great problems of the scheme is—How shall one get the radial velocities of the fainter stars; not of the really faint ones (that is beyond hoping for at present), but of good batches of stars down to the ninth magnitude? Can it be done by photographing a field through the objective prism, turning the prism through 180°, and repeating the exposure? If spectrum lines can be measured like stars, one exposure might be reduced to the other in just the same way that two ordinary star-photographs are compared for parallax or proper motion. We should thus obtain the radial velocity of every star relative to the mean of all; and if there were one or two standard stars in the field whose velocities had been determined absolutely with the slit spectrograph, the thing would be done. But practical experience suggests that there would be difficulties in this elegant scheme. In the first place, there are the optical distortions of prism as well as object-glass to be eliminated. If one spreads the reduction to include distortion terms, nearly all the weight is

* *The Observatory*, January 1906.

taken away from the determination of the principal unknowns. Shall the distortions be determined, then, by an independent investigation? There are solid reasons for believing that such a course is almost always bad. The results may be interesting qualitatively, but they do not necessarily apply quantitatively to plates taken under ordinary working conditions, when the temperature changes during exposure. These difficulties are fairly obvious. There is another, more grave, that is not apt to strike those unfamiliar with the working of objective prisms. The range of measurable magnitudes on an objective prism plate is very small. On an ordinary plate the brighter stars make enlarged images, and the faintest are only gray patches; but all are more or less measurable, and a range of four magnitudes at least can be dealt with satisfactorily on one and the same plate. With an objective prism plate it is altogether different. Over-exposure very soon blots out the fine lines in the image; under-exposure gives a spectrum in which the lines themselves are equally invisible, though the spectrum itself, as a band, is conspicuous enough. The consequence is that any given exposure gives measurable images over only a very small range of star magnitude, and in the comparatively small field of a large refractor, say one degree, there are not enough stars of the right magnitude to give a weighty reduction, nor are any brighter standard stars measurable on the same plate with the fainter. It is an old difficulty very much accentuated; and apparently the scheme is unworkable with ordinary photographic refractors. But it is not clear that all these objections arise when a great portrait-lens like the Bruce telescope at Arequipa is used, at any rate, would rapidly become big.

That his demand for velocities in the line of sight by the thousand cannot be met, owing to the existence of these instrumental difficulties, does not in the least damp the conviction of the Member from Groningen that the thing has got to be done somehow: "the investigation is necessary cosmically"; he will not be content with stars down to about the seventh magnitude, which is the working limit for spectrographic velocities at present; and if people say it can't be done—well, he is content to have aspirations higher than other people.

The "cosmical necessity" for line of sight velocities of faint stars is much more than the mere desirability of a check upon the velocity of the Sun in space derived from parallactic proper motions even though the check-method has the very great advantage of being independent of the distance of the stars.

Campbell has found the remarkable result that the fainter bright stars have larger radial velocities than the brighter. The same thing comes out even more strikingly in a determination of the solar from the parallactic motion of those two classes of stars. And in general, from stars having the greatest astronomical proper motions you get the smallest radial velocities, *which is not necessarily the consequence of their motion being mainly at right angles to the line of sight*, as one might at first suppose. It must be confessed that there seems to be something uncanny about this proposition in the theory of distribution. We had one evening an immense argument about it; discovered at the close that we had unconsciously been adopting quite different fundamental hypotheses; and never had an opportunity of returning to the subject. But as the fact, at any rate, seems to be certain, there is evidently abundant necessity for pushing the determination of radial velocities as far as instruments will go, or even rather farther. In one way or another faint stars must be got, and it is impossible to rest content with the present limits of magnitude.

Nevertheless the Member from Groningen would be very glad if people who have in their possession, and have had for years, hundreds of line of sight velocities for the brighter stars, would perceive that he has been hinting for some time that brief publication, or communication in advance of publication, would be very much appreciated by a man who has found a big new fact—the systematic "streaming" of stars—and finds himself brought to a standstill for want of data which are being held in reserve for someone else's *magnum opus*. In his paper which will be printed in full in the forthcoming B.A. report of the South African meeting, he refers sadly to the fact "that the materials for a crucial test of the whole theory by means of these radial velocities are even now in hand in the ledgers of American astronomers—alas! not yet in published form."

It has already been made clear that the Member from Groningen has a splendid faith in the power of observers and instruments to obtain the photographs which his astronomical laboratory is waiting to discuss. He wants Durchmusterung plates taken, to get parallaxes of stars down to the fourteenth magnitude. He does not think the difference of parallax between tenth magnitude and fourteenth will be more than 0″.003 or 0″.004, but is confident that plates can be taken giving a probable error of 0″.01 for each star. "That is a fact; and so with a few thousand stars it can be done. You could not get system-

atic error [by the photographic Durchmusterung method] if you tried. The whole matter is that we are going to find out what the Milky Way is; and as a whole the Milky Way is determined by stars of the twelfth magnitude."

It is quite evident that there is no hope of dealing with such great numbers of faint stars individually. Something like the Durchmusterung method as illustrated in the first part of the Groningen publications is the only possibility. We must take it or leave it. But the method is singularly arduous and difficult to work in a poor climate, and there is unfortunately some truth in the opinion frankly expressed at a meeting of Section A at Cape Town, that those who had first taken it were now leaving it.

All this discussion of the great scheme consumed several days, but time was left for a Society ascent of Table Mountain, and for individual pilgrimages to two historical sites. The place where Lacaille's observatory stood is in the busiest part of the town, in Strand Street, near the railway station. All traces of his house have now disappeared; but a few years ago the South African Philosophical Society placed on the wall of the building which now occupies the site—the shop of Messrs. Cooke & Sons, of York, London, and Cape Town—a very beautiful bronze tablet, with the inscription: "On this site l'Abbé de la Caille carried on his astronomical observations in the years 1751 and 1752 A. D." Above is the Southern Cross over Table Mountain and Bay; in the lower corners of the panel a quadrant and a diagram of the triangulation for Lacaille's geodetic arc.

The famous estate of Feldhausen has been sadly spoiled during the last few years. The grounds are covered by suburban streets. The beautiful old house, an excellent piece of the old Dutch colonial architecture, with thatched roof, and a splendid tree on each side of the steps leading up to the stoep, has been altogether spoiled, roofed with corrugated iron, given a cast-iron verandah of the pattern hideously common throughout Cape Town, and turned into a surgical nursing home. The old brass sundial in the garden, its last beauty, was stolen a few months ago. The obelisk erected by Herschel's friends after his departure stands rather forlorn by the playground of an elementary school. On one side is a new-looking brass with the inscription: "Here stood from MDCCCXXXIV to MDCCCXXXVIII the reflecting telescope of Sir John F. W. Herschel, Baronet, who during a residence of four years in this colony contributed as largely by his benevolent exertions to the cause of education and humanity as by his eminent talents to the discovery of scientific truth. Erected

MDCCCXLI." The astronomer may be allowed to think that this unhappy sentence in the vulgar tongue rather obscures than makes plain the circumstances which the obelisk was designed by Herschel's friends to commemorate; perhaps it accounts for the fact which Sir David Gill lamented a little while ago, that the recollection of Herschel was being lost in the very place where he worked. The otherwise admirable Cape Town handbook published for the British Association visit gives this inscription, but omits to say that on the other side of the monument there is the original brass, showing how much better some things can be put in Latin:—

SPECULUM SESQUIPEDALE
IN ANGLIA
PROPRIIS FACTUM MANIBUS
HOC SITU POSUIT
JOHANNES F. W. HERSCHEL
ET QUATTUOR PER ANNOS
QUOAD LONGISSIME MICANT
ORBES NEBULAEQUE COELESTES
SEDES EORUM ET SPECIES
PERITISSIME NOTAVIT.
SIC OPUS ILLUD INSIGNE
A PATRE CLARO ET A SEIPSO
BOREALI SUB COELO INCEPTUM
EODEM QUASI OCULO
IN AFRICA
FILIUS PIE PERFECIT.

The two inscriptions contain the same number of words. The Latin gets in the whole achievement of the Herschels. How curious that with this model before him the author of the inscription that is probably more often read should tell the boys that on their playground stood the telescope of a benevolent philanthropic baronet and scientific celebrity, but leaves them to guess what he did with the telescope standing in his garden.

The ascent of Table Mountain by a larger (and heavier) section of the Society was all the pleasanter in that the summit was not reached. One of the members from Cambridge is an old lover of the mountain, and led us a charming way through the forests of silver trees, up over slopes covered with geranium and lobelia and gladiolus to the foot of Nursery Gorge, which gives access by a steep track to the lower plateau. There the Society lunched and slept, and instead of going the long dull stony walk to the top, went along the plateau and down by another way overlooking

the vineyards of Constantia, while the Junior Member from Groningen, who had started earlier and gone another way, waited in vain upon the summit. There may be finer day's walks in the world than that up the mountain from the Newlands side, but the writer knows of none, unless perhaps it is the trip from Odde to the Schaeggedalsfos that was made by a few on the '96 Eclipse Expedition to Norway.

So ended the first week at the Cape, and the freedom of the Astronomical Society of the Atlantic. The Monday brought the intermediate steamer 'Durham Castle' which had not hurried itself since we passed it off Ushant 22 days before. The reception Room was opened. The avalanche of books and paper which greets the B. A. wherever it may meet was poured out in triple volume by the representatives of all colonies in South Africa, and in a fashion peculiar to the country everything at the last possible moment suddenly got into order in the splendid new City Hall, ready for the arrival of the President and his Address upon the morrow. A. R. H.

PLANET NOTES FOR MARCH 1906.

H. C. WILSON.

Mercury will be at greatest elongation, east from the Sun 18° 31′ on March 18, and therefore will be visible as morning star for a few days in the middle of the month. On March 28, the two planets Mercury and Venus will be in conjunction in right ascension, Mercury being about five degrees north of Venus. Both planets will then be too close to the Sun for observation.

Venus is just coming out from behind the Sun; having been at superior conjunction February 13.

Mars all must have observed during December, when the ruddy planet and the golden Saturn were in conjunction in the southwestern sky, and during the weeks night since when the relative movement of the twin stars has been so noticeable from to night. During March Mars will move northeastward through Pisces into the constellation Aries. The planet is so far from the earth that its apparent diameter is reduced to less than five seconds of arc.

Jupiter will be seen in the western sky in the evening during March, and will be an object well worth our study on such evenings as shall be mild. The weather never can be depended upon during this month but it is to be expected that there will be some good nights. Jupiter's apparent diameter in March will be about 35″.

Saturn having just passed conjunction with the Sun is not in position to be observed.

Uranus will be at quadrature, 90° west from the Sun, on March 29, so that it may be observed in the morning hours. It will be near the meridian at seven o'clock.

Neptune will be at quadrature, 90° east from the Sun March 28, and is in very convenient position for early evening observation. The planet may be found with the aid of a good telescope, among the faint stars about four degrees east from the star μ of the constellation Gemini.

Occultations Visible at Washington.

Date 1906.	Star's Name	Magnitude.	IMMERSION. Washington M. T.	Angle f'm N pt.	EMERSION. Washington M.T.	Angle f'm N pt.	Duration.
			h m	°	h m	°	h m
Mar 2	75 Tauri	5.2	5 17	69	6 51	259	1 34
2	B. A. C. 1406	6.5	9 31	162	9 46	185	0 15
2	α Tauri	1.1	10 30	110	11 30	240	1 00
4	71 Orionis	5.1	8 21	88	9 49	273	1 28
6	ζ Cancri	4.6	13 56	57	14 37	331	0 41
7	π^1 Cancri	6.4	16 17	59	16 53	333	0 36
8	ν Leonis	5.0	10 53	108	12 14	298	1 21
9	X Leonis	4.6	17 32	148	18 14	253	0 42
12	80 Virginis	5.6	7 55	114	8 49	288	0 54
12	n Virginis	6.5	14 56	104	16 10	308	1 14
13	ξ^2 Libræ	5.7	20 10	38	20 34	350	0 24
14	Bradley 1987	6.5	14 34	82	15 43	322	1 09
15	24 Scorpii	5.0	14 12	51	14 52	346	0 40

Phenomena of Jupiter's Satellites.

[Central Standard Time.]

The hours after Midnight are numbered 12h, 13h, 14h, etc.

	h	m			h	m	
Mar. 1	5	58	III Oc. Dis.	Mar. 12	7	32	III Sh. Eg.
	8	07	III Oc. Re.	13	7	58	II Sh. In.
	11	20	I Oc. Dis.		8	07	II Tr. Eg.
	11	23	III Ec. Dis.		10	37	II Sh. Eg.
2	7	37	I Tr. In.	17	8	54	I Oc. Dis.
	8	56	I Sh. In.	18	6	03	I Tr. In.
	9	51	I Tr. Eg.		7	15	I Sh. In
	11	09	I Sh. Eg.		8	17	I Tr. Eg.
3	8	27	I Ec. Re.		9	29	I Sh. Eg.
4	5	38	I Sh. Eg.	19	6	46	III Tr. Eg.
	7	40	II Oc. Dis.		6	47	I Ec. Re.
6	7	59	II Sh. Eg.		9	25	III Sh. In.
8	10	08	III Oc. Dis.	20	8	12	II Tr. In.
9	9	35	I Tr. In.	22	7	22	II Ec. Re
	10	51	I Sh. In.	25	8	02	I Tr. In.
10	6	56	I Oc. Dis.		9	10	I Sh. In.
	10	23	I Ec. Re.		10	16	I Tr. Eg.
11	6	18	I Tr. Eg.	26	8	43	I Ec. Re.
	7	33	I Sh. Eg.		8	50	III Tr. In.
	10	21	II Oc. Dis.	27	5	53	I Sh. Eg.

Note.—In., denotes ingress; Eg., egress; Dis., disappearance; Re., reappearance; Ec., eclipse; Oc., denotes occultation; Tr., transit of the satellite; Sh., transit of the shadow.

Ephemeris for Physical Observations of the Sun.

1906.	Greenwich Mean Noon. P.	D.	L.	1906.	Greenwich Mean Noon. P.	D.	L.
	° ′	° ′	° ′		° ′	° ′	° ′
Jan. 1	+ 2 22	− 3 11	275 29	July 5	− 1 0	+3 27	353 44
6	− 0 4	3 44	209 39	10	+ 1 17	3 58	287 33
11	2 29	4 17	143 49	15	3 33	4 28	221 24
16	4 53	4 47	77 58	20	5 45	4 55	155 12
21	7 13	5 15	12 8	25	7 55	5 21	89 4
26	9 27	5 41	306 16	30	9 59	5 44	22 57
31	11 36	6 3	240 29	Aug. 4	12 0	6 5	316 48
Feb. 5	13 34	6 23	174 39	9	13 55	6 24	250 43
10	15 33	6 40	108 50	14	15 42	6 40	184 36
15	17 20	6 53	42 58	19	17 24	6 53	118 31
20	18 58	7 3	337 7	24	18 58	7 3	52 28
25	20 28	7 11	271 16	29	20 23	7 10	346 24
Mar. 2	21 48	7 14	205 26	Sept. 3	21 41	7 14	280 22
7	22 59	7 15	139 33	8	22 51	7 15	214 17
12	24 0	7 12	73 38	13	23 52	7 13	148 17
17	24 51	7 5	7 44	18	24 43	7 7	82 17
22	25 32	6 56	301 49	23	15 24	6 57	16 17
27	26 1	6 43	235 54	28	25 56	6 47	310 19
Apr. 1	26 22	6 28	169 56	Oct. 3	26 18	6 33	244 19
6	26 30	6 9	103 56	8	26 29	6 15	178 20
11	26 27	5 49	37 57	13	26 28	5 55	113 23
16	26 13	5 25	331 57	18	26 17	5 32	46 27
21	25 50	4 59	265 55	23	25 54	5 6	340 30
26	25 14	4 31	199 51	28	25 20	4 38	274 34
May 1	24 26	4 2	133 45	Nov. 2	24 33	4 8	208 38
6	23 30	3 30	67 40	7	23 35	3 36	142 43
11	22 22	2 58	1 33	12	22 26	3 2	76 47
16	21 4	2 24	295 26	17	20 2	3 27	10 53
21	19 36	1 49	229 18	22	19 29	1 50	304 57
26	17 58	1 13	163 7	28	17 48	1 13	239 4
31	16 12	0 37	96 58	Dec. 2	15 50	+ 0 35	173 10
June 5	14 18	−0 1	30 48	7	13 51	− 0 4	107 17
10	12 18	+0 35	324 38	12	11 42	0 42	41 24
15	10 12	1 12	258 28	17	9 26	1 20	335 31
20	8 1	1 47	192 15	22	7 5	1 57	269 40
52	5 48	2 21	126 5	27	4 41	2 34	203 49
30	− 3 52	+2 55	59 54	32	+ 2 14	− 3 10	137 57

The position-angle of the Sun's axis, P, is the position-angle of the N. end of the axis from the N. point of the Sun, read in the direction N., E., S., W. In computing D (the heliographic latitude of the centre of the Sun's disk), the inclination of the Sun's axis to the ecliptic has been assumed to be 82° 45′, and the longitude of the ascending node to be 74° 26′. In computing L (the heliographic longitude of the centre of the Sun's disk), the Sun's period of rotation has been assumed to be 25.38 days, and the meridian which passed through the ascending node at the epoch 1854.0 has been taken as the zero meridian.

Companion to the Observatory, 1906.

Sun-Spot Observations 1905.

Month	No. of Obs.	N. of Equator No. Groups	N. of Equator Av. Lat.	S. of Equator No. Groups	S. of Equator Av. Lat.	Av. No. at each Obs.	New Groups.
January	15	6	+12.8	7	−18.3	4.3	13.
February	18	8	11.9	11	18.3	4.6	16.
March	18	9	12.0	8	19.5	2.9	12.
April	12	5	13.4	4	19.1	3.2	8.
May	23	7	11.6	6	18.8	2.6	10
June	12	3	10.8	6	19.9	3.6	6
August	2	--	——	--	——	4.0	4.
September	16	4	8.8	2	19.3	2.8	6.
October	15	10	9.5	5	12.8	3.8	14.
November	14	16	10.0	10	17.6	5.3	20.
December	6	4	+10.1	5	−15.9	3.5	6.
Total	151	72		64			115

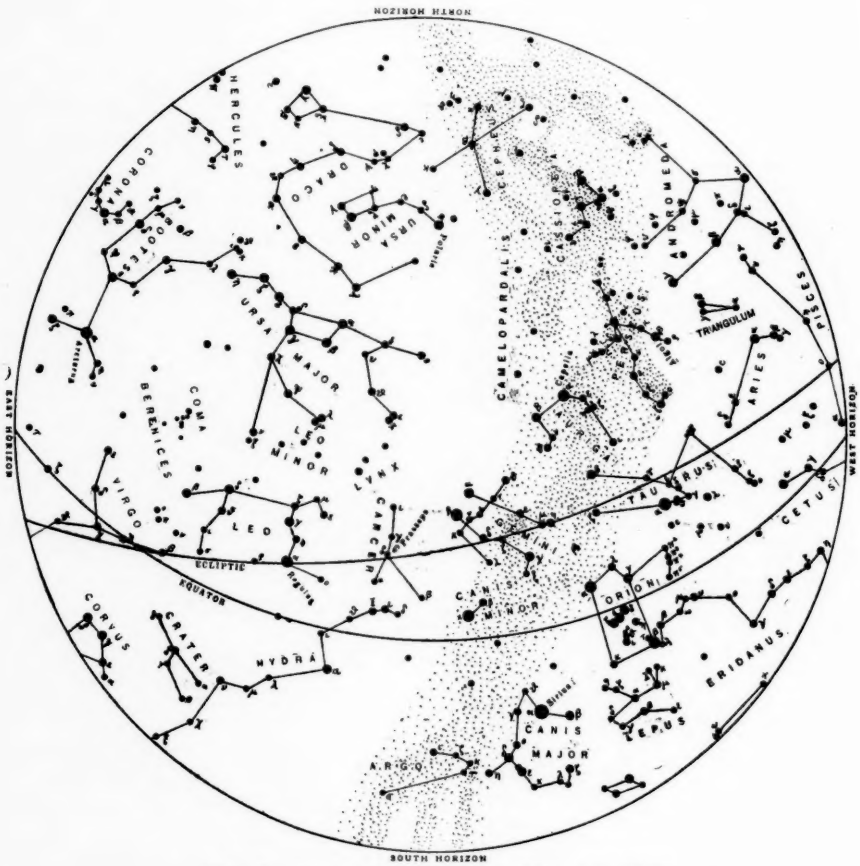
Average number at each observation	3.72
Average latitude of spots north of equator	+11.09
Average latitude of spots south of equator	−17.95

Only three observations were made when no spots were visible. These were upon March 14, May 23 and 24.

Observations were usually made by projecting the image of the Sun upon a screen attached to the eight-inch equatorial telescope, approximate latitude, being obtained from Thomson's Disks. Fifteen of these observations, from August 1st to September 20th were made at Chicago, with an inch and one-half glass. Latitudes for these dates were not recorded.

JENNIE B. LASBY.

Mount Holyoke College Observatory.



THE CONSTELLATIONS AT 9 P. M., MARCH 1, 1906.

COMET AND ASTEROID NOTES.

Search Ephemeris for Comet 1892 V (Barnard).—In *A. N.* 4063 Mr. J. Coniel gives a rough search ephemeris for the faint periodic comet discovered by Barnard in 1892, the period of which is somewhat uncertain. The ephemeris extends only to January 14. The positions for the last two dates may enable the reader to carry forward the approximate region in which the comet should be found. The true anomaly (v) of the comet is assumed as unknown and the position of the comet is given for each 5° of v.

For v =		+ 45°	+ 40°	+ 35°	+ 30°	+ 25°
Jan. 10	α	$1^h\ 39^m$	$1^h\ 15^m$	$0^h\ 53^m$	$0^h\ 33^m$	$0^h\ 14^m$
	δ	−12° 54′	−11° 12′	−9° 37′	−8° 11′	−6° 54′
14	α	$1^h\ 38^m$	$1^h\ 15^m$	$0^h\ 55^m$	$0^h\ 35^m$	$0^h\ 17^m$
	δ	−11° 50′	−10° 13′	−8° 46′	−7° 26′	−6° 11′

Comet 1894 IV. Permit me to call your attention to an error in the paragraph concerning Comet 1894 IV printed on page 51 of the January number of Popular Astronomy. The date given for the next perihelion passage of this comet has been derived, apparently, from the osculating elements for 1894, A. N. No. 3606-7, or possibly, from the elements of Chandler printed in A. J. No. 338. The period corresponding to these elements is about 5.9 years, which would result in a perihelion passage for 1906, July 1, or thereabouts, as stated in the paragraph referred to. But in 1896-7 the comet was in close conjunction with Jupiter. For over six months the distance comet-Jupiter was less than half an astronomical unit with a minimum of 0.43 on 1897, April 7. The resulting perturbations were very large, especially in the longitude of the node and in the mean daily motion (A. N. No. 3656.) This period was increased to 6.4 years and the following perihelion passage was delayed until 1901, February 14. Since the comet has been free from large disturbing forces during the interval 1901-7, the next perihelion passage may be expected about 1907, July 6. The conditions of visibility or the approaching return are not unlike those of 1894, so that, at best, the comet will probably be a difficult object.

St. Louis, Mo. F. H. SEARES.

Elements and Ephemeris of Comet *c* 1905 (Giacobini). The results given below were derived from the following observations:

1905 Gr. M. T.		Comet's Apparent α		δ		Observer.
Dec.	6.6837	14^h	$21^m\ 39^s.4$	+20°	59′ 29″	Giacobini (Nice)
	12.0773	14	48 05 .7	+18	25 56	Smith
	17.0768	15	15 04 .9	+15	32 45	Smith

The geocentric distance and the heliocentric velocities for the middle date derived from the preliminary orbit given in Bulletin No. 87, and the observed position for the middle date, corrected for parallax and aberration, were adopted as a first approximation to the constants of the orbit. These give the residuals.

		I	III
(O — C)	$\Delta\alpha \cos\delta$	−36″	+04′ 22″
	$\Delta\delta$	+16	−02 03

Differential corrections to the geocentric distance and heliocentric velocities were derived by Leuschner's adaption of his "Short Method" to the computation

of a parabola. As a check a second correction was attempted, but the residuals could not be removed completely.

ELEMENTS.

$T = 1906$ Jan. 22.41845 Gr. M. T.
$q = 0.217605$

Mean Equinox and Ecliptic 1905.0		Mean Equinox and Ecliptic 1906.0	
$\omega =$	199° 01′ 28″.1	$\omega =$	199° 01′ 28″.8
$\Omega =$	92 01 10 .8	$\Omega =$	92 02 00 .5
$\iota =$	43 48 36 .8	$\iota =$	43 38 36 .7

	I	III
(O − C) $\Delta\delta$	+08″.6	+02″.4

CONSTANTS FOR THE EQUATOR 1905.0

$x = r$ [9.859773] sin (21° 48′ 51″.8 + v)
$y = r$ [9.984104] sin (307 02 02 .9 + v)
$z = r$ [9.868726] sin (231 34 42 .7 + v)

CONSTANTS FOR THE EQUATOR 1906.0.

$x = r$ [9.859776] sin (21° 50′ 01″.0 + v)
$y = r$ [9.984124] sin (307 02 36 .1 + v)
$z = r$ [9.868690] sin (231 34 52 .2 + v)

In the computation of the following ephemeris I was assisted by Mr. A. J. Champreux.

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT.

1905		True α			True δ			log r	log Δ	Br.
Dec.	23.5	15h	53m	32s.7	+10°	57′	13″	9.9509	0.0755	3.5
	25.5	16	06	23 .8	+09	18	08		0.0671	
	27.5		19	40 .0	+07	32	28	9.9042	0.0595	
	29.5		33	21 .6	+05	40	12		0.0531	
Dec.	31.5	16	47	28 .2	+03	41	31	9.8497	0.0479	
1906										
Jan.	2.5	17	02	00 .1	+01	36	35		0.0446	
	4.5		16	57 .8	−00	34	15	9.7849	0.0416	8.8
	6.5		32	22 .6	−02	50	30		0.0408	
	8.5	17	48	16 .9	−05	11	47	9.7056	0.0417	
	10.5	18	04	45 .1	−07	37	35		0.0442	
	12.5		21	54 .7	−10	07	31	9.6061	0.0482	
	14.5		39	57 .9	−12	41	06		0.0537	24.8
	16.5	18	59	13 .8	−15	17	36	9.4817	0.0603	32.4
	18.5	19	20	09 .5	−17	54	56		0.0671	40.9
	20.5	19	43	14 .8	−20	27	27	9.3593	0.0728	53.8
	22.5	20	08	35 .3	−22	42	49		0.0758	58.6
	24.5	20	35	21 .8	−24	25	22	9.3629	0.0752	52.3
	26.5	21	02	16 .1	−25	27	19		0.0721	40.8
	28.5		28	25 .5	−25	51	25	9.4871	0.0683	30.5
Jan.	30.5	21	53	28 .2	−25	44	25		0.0652	22.7
Mar.	1.5	01	48	11 .0	−06	02	44	0.0294	0.1806	1.5
Apr.	2.5	03	29	02 .6	+07	09	50	0.2252	0.3627	0.3

Brightness December 6 = 1.00

R. T. CRAWFORD.

Lick Observatory Bulletin, Number 88.

Ephemeris of Holmes' Comet.—In *A. N.* 4063 there is also a short ephemeris by H. J. Zwiers for Holmes' periodic comet, and this also does not extend into February. The last three dates are as follows:

1906	α app			δ app.			$1:r^2\Delta^2$
	h	m	s	°	′	″	
Jan. 21	21	26	07.0	−16	28	55	0.0228
25		34	15.0	−15	26	26	
29	21	42	20.9	−14	22	49	0.0227

VARIABLE STARS.

Approximate Magnitudes of Variable Stars on Jan. 1, 1906.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900. h	m	Decl. 1900. °	′	Magn.	Name.	R. A. 1900. h	m	Decl. 1900. °	′	Magn.
X Androm.	0	10.8	+46	27	11.3*d*	S Can. Min.	7	27.3	+ 8	32	7.9*d*
T "		17.2	+26	26	11.3*d*	T " "		28.4	+11	58	11 *i*
R "		18.8	+38	1	14	U " "		35.9	+ 8	37	9.3 *i*
S Ceti		19.0	− 9	53	13.8	S Gemin.		37.0	+23	41	9.2*d*
Y Cephei		31.3	+79	48	11.7	T "		43.3	+23	59	<12
U Cassiop.		40.8	+47	43	8.5*d*	U "		49.2	+22	16	<12
V Androm.		44.6	+35	6	10.3 *i*	R Cancri	8	11.0	+12	2	8.1
RR "		45.9	+33	50	11.3*d*	V "		16.0	+17	36	11.0*d*
W Cassiop.		49.0	+58	1	12.3*d*	S Hydrae		48.4	+ 3	27	8.8 *i*
S "	1	12.3	+72	5	15	T "		50.8	− 8	46	10
S Piscium		12.4	+ 8	24	12.3*d*	T Cancri		51.0	+20	14	9.8
U "		17.7	+12	21	11.3	W "	9	4.0	+25	39	11.5
R "		25.5	+ 2	22	13.3*d*	Y Draco.		31.1	+78	18	11.9*d*
RU Androm.		32.8	+38	10	9.8	R Leo. Min.		39.6	+34	58	8.0*d*
Y Androm.		33.7	+38	50	<12	R Leonis		42.2	+11	54	9.5 *i*
X Cassiop.		49.8	+58	46	11 *d*	V "		54.5	+21	44	<12
U Persei		52.9	+54	20	11.5*d*	R Urs. Maj.	10	37.6	+69	18	13
S Arietis		59.3	+12	3	12.5*d*	T " "	12	31.8	+60	2	9.0*d*
R "	2	10.4	+24	35	8.5 *i*	S " "		39.6	+61	38	12.5*d*
W Androm.		11.2	+43	50	8	S Bootis	14	19.5	+54	16	14
o Ceti		14.3	− 3	26	4.2 *i*	R Camelop.		25.1	+84	17	9.0 *i*
S Persei		15.7	+58	8	9.7*d*	S Urs. Min	15	33.4	+78	38	9.0*d*
R Ceti		20.9	− 0	38	8.9 *i*	R Coronae		44.4	+28	28	6
R Triang.		31.0	+33	50	7.3 *i*	V "		46.0	+39	52	12
T Arietis		42.8	+17	6	10.0*d*	R Serpentis		46.1	+15	26	<12
W Persei		43.2	+56	34	10.3*d*	RR Herc.	16	1.5	+50	46	9
U Arietis	3	5.5	+14	25	7.8 *i*	R "		1.7	+18	38	<13
X Ceti		14.3	− 1	26	12.2*d*	W "		31.7	+37	32	13
R Persei		23.7	+35	20	8.9 *i*	R Draco.		32.4	+66	58	<12
S Fornacis		41.9	−24	42	8	RS Herc.	17	17.5	+23	1	<12
T Tauri	4	16.2	+19	18	11.7*d*	V Draco.		56.3	+54	53	10.5
W "		22.2	+15	49	8.5 *i*	T Herc.	18	5.3	+31	0	13
R "		22.8	+ 9	56	11.2*d*	RW Lyrae		42 2	+43	32	12 *i*
S "		23.7	+ 9	44	14.5	V "	19	5.2	+29	30	10 *i*
T Camelop.		30.4	+65	57	8.5 *i*	RU "		9.1	+41	8	<12
X Camelop		32.6	+74	56	11.5*d*	U Draco.		9.9	+67	7	11.8*d*
V Tauri		46.2	+17	22	13 *d*	TZ Cygni		13.4	+50	0	12.0*d*
R Orionis		53.6	+ 7	59	10.1*d*	U Lyrae		16.6	+37	42	12 *d*
R Leporis		55.0	−14	57	9.5 *i*	T Sagittae		17.2	+17	28	10.0*d*
T "	5	0.6	−22	2	8.5 *i*	TY Cygni		29.8	+28	6	<12
V Orionis		0.8	+ 3	58	12.6*d*	RT Aquilae		33.3	+11	29	12.3
R Aurigae		9.2	+53	28	13.1*d*	R Cygni		34.1	+49	58	11.5 *i*
W "		20.1	+36	49	12.0	RV Aquilae		35.9	+ 9	42	<12
S "		20.5	+34	.4	10.0*d*	RT Cygni		40.8	+48	32	8.4*d*
T Orionis		30.9	− 5	32	00.2*d*	X Aquilae		46.5	+ 4	12	9.0*d*
RR Tauri		33.3	+26	19	10	X Cygni		46.7	+32	40	5.5 *i*
U Aurigae		35.6	+31	59	10.7 *i*	RR Aquilae		52.4	− 2	11	<12
U Orionis		49.9	+20	10	12.0*d*	Z Cygni		58.6	+49	46	9.0*d*
V Aurigae	6	16.5	+47	45	12	S "	20	3.4	+57	42	14
V Monoc.		17.7	− 2	9	7	S Aquilae		7.0	+15	19	10.0 *i*
R "		33.7	+ 8	49	8	RS Cygni		9.8	+38	28	7.0 *i*
X Gemin.		40.7	+30	23	12.1	R Delph.		10.1	+ 8	47	8.7 *i*
Y Monoc.		51.3	+11	22	11	SX Cygni		11.6	+30	46	<12
X "		52.4	− 8	56	8	WX "		14.8	+37	8	10.5 *i*
R Lyncis		53.0	+55	28	9.5*d*	U "		16.5	+47	35	8.5*d*
R Gemin.	7	1.3	+22	52	10 5*d*	RW "		25.2	+39	39	9.5*d*
V Can. Min.		1.5	+ 9	1	12	Z Delph.		28.1	+17	6	<12
RR Monoc.		12.4	+ 1	17	<12	ST Cygni		29.9	+54	38	12.0*d*
V Gemin.		17.6	+13	7	11.6*d*	Y Delph.		36.8	+11	30	<12

Approximate Magnitude of Variable Stars on Jan. 1, 1906.—
(Continued.)

Name.	R. A. 1900. h m	Decl. 1900. ° ′	Magn.	Name.	R.A. 1900. h m	Decl. 1900. ° ′	Magn.
S Delph. 20	38.5	+16 44	12.0*d*	RS Pegasi 22	7.4	+14 4	11.1*d*
V "	43.2	+18 58	<12	X Aquarii	13.2	−21 24	9.0*d*
T Aquarii	44.7	− 5 31	12.0*d*	RT "	17.7	−22 34	8.9 *i*
RZ Cygni	48.5	+46 59	<12	T Lacertae	17.9	+33 52	9.9*d*
X Delph.	50.3	+17 16	9.3*d*	S "	24.6	+39 48	10.5*d*
UX Cygni	50.9	+30 2	11.8	R "	38.8	+41 51	12 *i*
R Vulpec.	59.9	+23 26	12.0*d*	S Aquarii	51.8	−20 53	8.9*d*
X Cephei 21	3.6	+82 40	13.5*d*	R Pegasi 23	01.6	+10 0	10.8*d*
T "	8.2	+68 5	8.6 *i*	V Cassiop.	7.4	+59 8	11.0*d*
R Equilei	8.4	+12 23	12.2*d*	W Pegasi	14.8	+25 44	8.5 *i*
X Pegasi	16.3	+14 2	<12	S "	15.5	+ 8 22	10.0*d*
S Cephei	36.5	+78 10	10.7*d*	R Aquarii	38.6	−15 50	9.5 *i*
RU Cygni	37.3	+53 52	9 *d*	Z Cassiop.	39.7	+56 2	12.0*d*
SS "	38.8	+43 8	11.8	Z Aquarii	47-1	−16 25	9.2*d*
RR Pegasi	40.0	+24 33	<1 2	RR Cassiop.	50.6	+53 10	11
V "	56.0	+ 5 38	12 *i*	R "	53.3	+50 50	12.5*d*
U Aquarii	57.9	−17 6	11.8*d*	Z Pegasi	55.0	+25 21	<12
RT Pegasi	59.8	+34 38	10.4*d*	W Ceti	57.0	−15 14	8.8*d*
T " 22	4.0	+12 3	9.5*d*	Y Cassiop.	58 2	+55 7	10.5
Y "	6.8	+13 52	<12				

The letter *i* denotes that the light is increasing, the letter *d* that the light is decreasing, the sign <, that the variable is fainter than the appended magnitude.

The above magnitudes have been compiled by Mr. Leon Campbell of the the Harvard College Observatory, from observations made at the Leander McCormick, Vassar College, Whiteside and Harvard Observatories.

Minima of Variable Stars of the Algol Type.

[Given to the nearest hour in Greenwich Mean Time. To reduce to Central Standard time subtract 6 hours, or for Eastern time subtract 5 hours.]

U Cephei.

	d	h
Mar.	1	0
	3	12
	6	0
	8	12
	11	0
	13	12
	15	23
	18	11
	20	23
	23	11
	25	23
	28	11
	30	22

Z Persei

	d	h
Mar.	2	2
	5	3
	8	5
	11	6
	14	7
	17	9
	20	10
	23	11
	26	13
	29	14

Algol.

	d	h
Mar.	2	8
	5	5
	8	2
	10	22
	13	19
	16	16
	19	13
	22	10
	25	7
	28	3
	31	0

RT Persei

	d	h
Mar.	1	7
	2	3
	3	0
	3	20
	4	16
	5	13
	6	9
	7	6
	8	2
	8	22
	9	19
	10	15

RT Persei

	d	h
Mar.	11	12
	12	8
	13	4
	14	1
	14	21
	15	17
	16	14
	17	10
	18	7
	19	23
	20	20
	21	16
	22	13
	23	9
	24	5
	25	2
	25	22
	26	19
	27	15
	28	11
	29	8
	30	4
	31	0
	31	21

λ Tauri

	d	h
Mar.	3	4
	7	3
	11	2
	15	1
	18	23
	22	22
	26	21
	30	20

R Canis Maj.

	d	h
Mar.	1	0
	2	4
	3	7
	4	10
	5	13
	6	17
	7	20
	8	23
	10	3
	11	6
	12	9
	13	12
	14	16
	15	19
	16	22

R Canis Maj.

	d	h
Mar.	18	1
	19	5
	20	8
	21	11
	22	14
	23	18
	24	21
	26	0
	27	3
	28	7
	29	10
	30	13
	31	16

Y Camelop.

	d	h
Mar.	1	15
	4	23
	8	6
	11	13
	14	21
	18	4
	21	11
	24	19
	28	2
	31	9

Minima of Variable Stars of the Algol Type.—Continued.

RR Puppis

	d	h
Mar.	2	10
	8	20
	15	6
	21	17
	28	3

V Puppis.

Mar.	4	5
	5	16
	7	2
	8	13
	10	0
	11	11
	12	22
	14	9
	15	20
	17	7
	18	18
	20	5
	21	16
	23	2
	24	13
	26	0
	27	11
	28	22
	30	9
	31	20

S Cancri.

Mar.	6	4
	15	16
	25	3

S Antliæ.

Mar.	1	7
	2	6
	3	5
	4	5
	5	4
	6	3
	7	3
	8	2
	9	1
	10	1
	11	0
	11	23
	12	23
	13	22
	14	21
	15	21
	16	20
	17	19
	18	19
	19	18
	20	17
	21	17
	23	15
	24	15
	25	14
	26	13
	27	13
	28	12
	29	11
	30	11
	31	10

S Velorum.

Mar.	5	22
	11	20
	17	19
	23	17
	29	15

W Urs. Maj.

Period 4^h 0.2^m

Mar. 1-31 14^h

RR Velorum

Mar.	2	18
	4	15
	6	11
	8	8
	10	4
	12	1
	13	21
	15	18
	17	14
	19	11
	21	7
	23	4
	25	0
	26	21
	28	17
	30	14

Z Draconis.

Mar.	1	12
	2	20
	4	5
	5	14
	6	22
	8	7
	9	15
	11	0
	12	9
	13	17
	15	2
	16	10
	17	19
	19	3
	20	12
	21	21
	23	5
	24	14
	25	22
	27	7
	28	15
	30	0
	31	9

δ Libræ

Mar.	1	9
	3	17
	6	0
	8	8
	10	16
	13	0
	15	8
	17	16
	20	0
	22	7
	24	15

δ Libræ

Mar.	26	23
	29	7
	31	15

U Coronæ

Mar.	2	17
	6	3
	9	14
	13	1
	16	12
	19	23
	23	10
	26	20
	30	7

R Aræ

Mar.	3	6
	7	16
	12	3
	16	13
	20	23
	25	9
	29	19

U Ophiuchi.

Mar.	1	2
	1	22
	2	18
	3	14
	4	11
	5	7
	6	3
	6	23
	7	19
	8	15
	9	11
	10	7
	11	4
	12	0
	12	20
	13	16
	14	12
	15	8
	16	4
	17	0
	17	21
	18	17
	19	13
	20	9
	21	5
	22	1
	22	21
	23	17
	24	14
	25	10
	26	6
	27	2
	27	22
	28	18
	29	14
	30	10
	31	7

Z Herculis.

Mar.	2	15
	4	18
	6	15
	8	18
	10	15
	12	18
	14	15
	16	18
	18	15
	20	18
	22	15
	24	17
	26	14
	28	17
	30	14

RS Sagittarii.

Mar.	2	2
	4	12
	6	22
	9	8
	11	18
	14	4
	16	14
	19	0
	21	10
	23	20
	26	6
	28	16
	31	2

V Serpentis.

Mar.	2	6
	5	17
	9	4
	12	15
	16	2
	19	12
	22	23
	26	10
	29	21

RX Herculis.

Mar.	1	18
	2	15
	3	13
	4	9
	5	7
	6	5
	7	2
	7	23
	8	21
	9	18
	10	15
	11	13
	12	10
	13	7
	14	5
	15	2
	15	23
	16	21
	17	18
	18	15
	19	13

RX Herculis.

Mar.	20	10
	21	7
	22	5
	23	2
	23	23
	24	21
	25	18
	26	15
	27	13
	28	10
	29	7
	30	5
	31	2

RU Lyræ

Mar.	4	2
	7	16
	11	7
	14	21
	18	12
	22	2
	25	16
	29	7

U Sagittarii.

Mar.	2	10
	5	19
	9	4
	12	14
	15	23
	19	8
	22	17
	26	2
	29	11

SY Cygni.

Mar.	5	11
	11	11
	17	11
	23	11
	29	11

WW Cygni.

Mar.	3	8
	6	15
	9	23
	13	6
	16	14
	19	22
	23	5
	26	13
	29	21

SW Cygni

Mar.	4	17
	9	7
	13	20
	18	10
	23	0
	27	14

VW Cygni.

Mar.	6	5
	14	15
	23	1
	31	12

Minima of Variable Stars of the Algol Type.—Continued.

UW Cygni		W Delphini		Y Cygni		VV Cygni		VV Cygni	
d	h	d	h	d	h	d	h	d	h
Mar. 1	2	Mar. 19	13	Mar. 15	20	Mar. 3	13	22	18
4	13	24	8	17	8	5	0	24	5
8	0	29	3	18	20	6	12	25	16
11	11	Y Cygni		20	8	7	23	27	4
14	22	Mar. 2	8	21	20	9	11	28	15
18	8	3	21	23	7	10	22	30	3
21	19	5	8	24	20	12	9	31	14
25	6	6	20	26	7	13	21	UZ Cygni	
28	17	8	8	27	20	15	8	Mar. 7	14
W Delphini		9	20	29	7	16	20		
Mar. 5	2	11	8	30	20	18	7		
9	22	12	20	VV Cygni		19	19		
14	17	14	8	Mar. 2	1	21	6		

Variable Stars of Short Period not of the Algol Type.

The times of maxima only are given; the times of minima may be obtained by subtracting the interval printed in parentheses under the name of the star.

Y Aurigæ		W Carinæ		V Centauri		X Sagittarii		U Aquilæ	
d	h	d	h	d	h	d	h	d	h
(— 17	31)	(— 1	0)	(— 1	12)	(— 2	21)	(— 2	5)
Mar. 2	8	Mar. 2	16	Mar. 2	13	Mar. 7	17	Mar. 1	10
6	4	7	1	8	1	14	17	8	10
10	1	11	9	13	13	21	18	15	11
13	22	15	18	19	1	28	18	22	12
17	18	20	3	24	12	Y Ophiuchi		29	12
21	15	24	12	30	0	(— 6	5)	U Vulpeculae	
25	11	28	21	R Triang. Austr.		Mar. 1	17	(— 2	3)
29	8	S Muscæ		(— 1	10)	18	20	Mar. 2	14
T Monocerotis		(— 3	11)	Mar. 2	7	W Sagittarii		10	14
(— 7	22)	Mar. 9	6	5	16	(— 3	0)	18	13
Mar. 8	2	18	22	9	1	Mar. 1	14	26	13
Apr. 4	2	28	14	12	11	9	5	SU Cygni	
W Geminorum		T Crucis		15	20	16	19	(1—	8)
(— 2	16)	(— 2	1)	19	5	24	9	Mar. 1	18
Mar. 6	18	Mar. 6	21	22	15	31	23	5	15
14	12	13	14	26	0	Y Sagittarii		9	11
22	6	20	8	29	9	(— 2	2)	13	7
29	23	27	2	S Triang. Austr.		Mar. 6	9	17	4
ξ Geminorum		R Crucis		(— 6	0)	12	4	21	0
(— 5	0)	(— 1	9)	Mar. 4	10	17	22	24	20
Mar. 1	1	Mar. 5	19	10	18	23	17	28	17
11	4	11	15	17	2	29	11	η Aquilae	
21	8	17	10	23	10	U Sagittarii		(— 2	9)
31	12	23	6	29	17	(— 3	0)	Mar. 4	9
V Carinæ		29	2	S Normae		5	14	11	13
(— 2	4)	S Crucis		(— 4	9)	12	7	18	17
Mar. 6	8	(— 1	12)	Mar. 2	13	19	1	25	22
13	1	Mar. 3	9	12	7	25	19	S Sagittae	
19	17	8	2	22	1	β Lyræ		(— 3	10)
26	10	12	18	31	19	[— 3	2]	Mar. 4	10
T Velorum		17	11	R V Scorpii		[— 3	7]	12	19
(— 1	9)	22	3	(— 1	10)	Mar. 9	12	21	4
Mar. 2	20	26	20	Mar. 5	3	15	23	29	14
7	10	31	12	11	4	22	10	X Cygni	
12	2	W Virginis		17	6	28	21	(— 6	5)
16	17	(— 8	4)	23	7	κ Pavonis		Mar. 15	20
21	8	Mar. 15	2	29	9	(— 4	9)	Apr. 1	5
26	0	Apr. 1	8			Mar. 5	2		
30	15					14	4		
						23	6		

Variable Stars of Short Period not of the Algol Type.—Continued.

T Vulpeculae

	d	h
	(−1	10)
Mar.	4	12
	8	23
	13	9
	17	20
	22	6
	26	16
	31	3

WZ Cygni minimum

	d	h
Mar.	2	2

WZ Cygni

	d	h
Mar.	3	6
	4	10
	5	14
	6	18
	7	22
	9	2
	10	6
	11	10
	12	14
	13	18
	14	22
	16	2

WZ Cygni

	d	h
	17	6
	18	10
	19	14
	20	18
	21	22
	23	3
	24	7
	25	11
	26	15
	27	19
	28	23
	30	3

WZ Cygni

	d	h
Mar.	31	7

TX Cygni

	d	h
	(−5	3)
Mar.	8	13
	23	6

VY Cygni

	d	h
	(−2	2)
Mar.	4	10
	12	7
	20	4
	28	0

δ Cephei

	d	h
	(−1	9)
Mar.	1	20
	7	4
	12	13
	17	22
	23	7
	28	15

Variables in the Vicinity of γ Aquilæ.—In *A. N.* 4056 Messrs. M and G. Wolf give a list of seven new variables found upon photographs of the region around the star γ Aquilae. They are numbered 109—115.1905, and are all faint stars, none of them being noted as brighter than eleventh magnitude. Separate charts of all seven variables are given.

Variables or Nova 116.1905 Arietis.—In *A. N.* 4056 Messrs. M. and G. Wolf call attention to a star of about the twelfth magnitude which appears on two plates taken November 6, 1905 and of which no trace is to be found on fourteen plates taken in the years 1895, 1898, 1901, 1902, 1903 and 1905, generally in the month of October or November. The position of the star for 1900.0 is

$$\alpha = 3^h\ 19^m\ 19^s.29 \quad \delta = +19^\circ\ 29'\ 38''.7.$$

Later information indicates that the star is waning rapidly in brightness.

Variability of β Herculis.—In *A. N* 4057 Mr. H. E. Lau of Copenhagen calls attention to the fact that in August and early in September 1905 β Herculis was below its normal magnitude. This star is a spectroscopic binary and the preliminary orbit elements by Dr. Reese give as the date of the last conjunction August 13, 1905. According to Dr. Curtiss the period $410^d.57$ is uncertain by about 5 days. Mr. Lau suggests that β Herculis is apparently to be counted among the Algol stars.

New Elements of the Variable Star W Geminorum.—In *A.N.* 4056 Mr. M. Luizet, of St. Genis-Laval, gives the following new elements of W Geminorum based upon the observations of several observers extending from 1895 to 1905:

$$\left.\begin{array}{l}\text{Maximum} = \text{J. D. } 2413266.35 \text{ (Paris m. t.)} \\ \text{Minimum} = \quad 2413263.44 \quad " \quad "\end{array}\right\} + 7^d.91603\ E,$$

or

$$\left.\begin{array}{l}\text{Maximum} = \text{March } 13, 1895, 8^h.4 \text{ (Paris m. t.)} \\ \text{Minimum} = \text{March } 10, 1895, 10^h.6 \quad " \quad "\end{array}\right\} + 7^d\ 21^h\ 59^m\ 05^s E.$$

The light-curve drawn by Luizet shows a secondary minimum just about one day after the principal maximum, followed eleven hours later by a secondary maximum. The following list of comparison stars used by Luizet may be of use to some of our readers:

	BD.	Light-steps.	Magnitude Potsdam	Magnitude H. C. O.
e	$+17^\circ.1275$	11.9	$6^m.30$	$6^m.19$
d	$+16\ .1178$	10.1	6 .59	6 .37
a	$+16\ .1201$	6.1	5 .85	6 .67
b	$+15\ .1233$	1.8	7 .36	7 .24
c	$+15\ .1255$	0.0	7 .62	7 .13

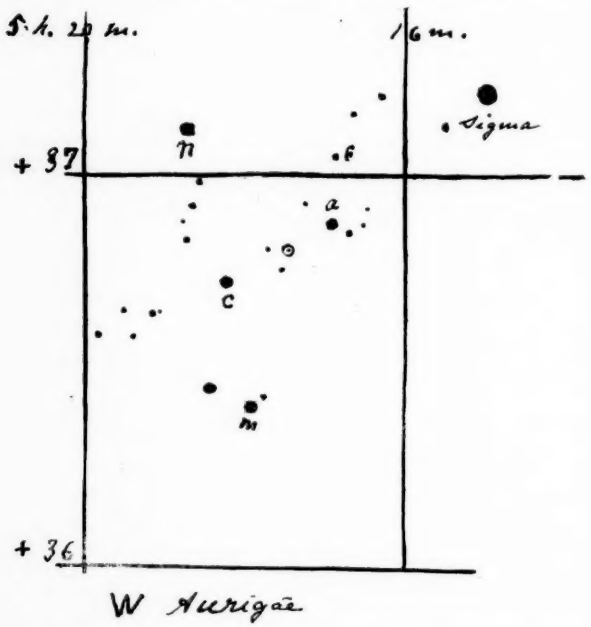
Variable Star Notes.

W AURIGÆ.

This variable was invisible in a four-inch lens on the clear nights of October and November, 1904, but passed a maximum of more than usual range in the following month.

1904 December 2. Barely discernible, dimmer than k. Night very clear.
4. Brighter than k, equal to l.
13. Equals a, less than c.
16. The same.
24 and 25. Brighter than a or c. Nights clear.
31. Brighter than c, less than n, equals m. This comparison star is about 9 magnitude.
1905 2, 4, 9, 10. Equal to m, less than n. Nights clear.
24, 28. Less than m, equal to a.

The well known comparison stars used by Mr. Parkhurst and other observ-



ers, were chiefly used in the above observations, but the high range required m and n without regard to alphabetical order.

The prediction in the *Companion to the Observatory* of maxima on January 10 and October 13, was fulfilled in the first case. The second was looked for with the following result.

1905 October 10. Brighter than l, equals f. Dimmer than a.
20, 26. The same.
November 3. Brighter than f, less than a.

13, 24. The same.
December 3. The same.
15. Equals l, brighter than k.
19. Less than k.
23. Invisible, k discernible though the night was not very clear.

V ORIONIS.

1905 September 27. Equals h, brighter than m.
October 20. The same. Altitude low.
November 29. Equals m.
December 19. Less than m, Not discernible.
24. The same. m is just visible.

A maximum was predicted for September 29 which may have occurred previous to that date. The comparison stars are closely adjacent to the variable, and appear on the chart in *Popular Astronomy* for October, 1905, page 469.

In the observations on the same page h is changed to n by a typographical error.

S CYGNI.

1904 June 3. About 11.5 magnitude. Dimmer than h.
10. Seems equal to h.
20. Equal to f.
July 10. Nearer to d than to f.
15. Equal to f.
31. Distinctly less than f. Night very clear.

Observations were not obtained on June 28, the date of expected maximum. The comparison stars used are those of the charts published by Harvard College 1891.

SS CYGNI.

1905 June 18. 9:45 P. M. Equals a and c, less than b.
22. 9:35 P. M. Equal to n.
26. 10:30 P. M. Of 11.5 magnitude.
27. 10:35 P. M. The same.
30. 9:40 P. M. The same.

The comparison stars are those in *Popular Astronomy* for September, 1897, page 271.

V CORONÆ.

The comparison stars used in the following observations of a decline from maximum of this variable are those lettered on the chart that appeared in *Popular Astronomy* for August and September, 1904, page 496.

1905, April 4. Brighter than c less than b. Night clear.
21. V, b and c seem equal. Night not very clear.
27. Brighter than d, less than c.
May 5. Brighter than d, less than b, equals c.
9. The same.
19. The same.
21. Slightly brighter than c.
31. Brighter than d, less than c.
June 1. The same.
10. Still unchanged. Distinctly brighter than e or f.

ROSE O'HALLORAN.

San Francisco, December 27, 1905.

GENERAL NOTES.

Sunspots and the Sun's Rotation. Father Ricard of Santa Clara, Cal., has written an interesting popular article on Sunspots and the rotation of the Sun referring especially to the activity of the solar surface at the present time. The article referred to is found in *The Bulletin*, San Francisco, December 4, 1905.

Is there Life on the Moon? Some one has written an account of Professor Pickering's work in relation to the Moon. under the title, *Is there Life on the Moon?* The evidences which seem to point to the possibility that there still may be some life on the cold and desolate surface of the Moon are variable spots that are not shadows. In these spots it is claimed that there are evidences of vegetation

The writer closes with this rather too strong statement: "The advances which have recently been made in selenography by Professor Pickering show that although the Moon is not a riotously luxuriant abode, it is anything but the lifeless orb commonly supposed. It may be desolate and cold, but it is not altogether dead."

Transmutation of Elements. The dissociation of physical matter and the transmutation of chemical elements has received new support from the scholarly presidential address of Professor G. H. Darwin before the British Association for the Advancement of Science at Cape Town, Africa, August 15, 1905, and by important experimental study at Cambridge by R. J. Stutt (See *Nature* August 17, 1905). Mr. Stutt claims that it is now proved that Radium is evolved from Uranium. Sir William Ramsey found Helium to be evolved from Radium, so it appears to be certain that Uranium passes into Radium, and Radium into Helium. In this address Professor Darwin was dealing with the general problem of the stability of matter, and the significance of Thompson's remarkable electric researches at Cambridge.

Forest Fires on Mt. Lowe. Professor George E. Hale, Director of the Solar Observatory on Mt. Wilson, sets us right in regard to the account of the forest fires on Mt. Lowe which was given in our last issue. In regard to that account Professor Hale says:

"It is evident that the *Times* reporter confused the Observatory on Echo Mountain with the Solar Observatory on Mt. Wilson. Fortunately the fire did not come within several miles of the Solar Observatory, and we were never in any fear that the buildings or instruments would be injured."

Wanganui Astronomical Society. Wanganui is located on the south west coast of the North Island of New Zealand. It is in longitude about 175° E. of Greenwich and 40° S. latitude. The first annual report of this Astronomical Society that we have seen has been forwarded by J. T. Ward the Director of the Observatory. Mr. Ward has been occupied part of his time with work on double stars. The report shows much interest in Astronomy in this part of the island. The newly elected President of the Wanganui Astronomical Society is Mr. H. Sargeant.

Reporting Observations. There are thousands of observers in different parts of the world that are engaged in making astronomical observations with

some fair degree of regularity. Now, if one tenth, or, one one-hundredth part of these observers would send a brief account of the unusual things they see to Journals of established reputation there would be brought to the many readers of these publications, a hundred-fold of help beyond that they can now get. The result of all this would be to quicken and promote investigation along many kindred lines of science that are waiting for this kind of help.

Astro-Photographic Objective for Cincinnati Observatory. The Cincinnati Observatory has lately placed an order with T. Cooke & Sons, England, for a triple Astro-Photographic objective of 9½ inches aperture. The focal length will be as nearly as possible to 67.7 inches, so that one millimeter on the photographic plate may equal two minutes of arc. The scale of the plates will thus be one-half that of the International Astrographic negatives.

Cooke & Sons state that the objective will give good definition over a field fully 15 degrees in diameter.

The ratio of aperture to focal length being about 1 : 7, they hope to do very satisfactory work in photographing comets, nebulæ and asteroids. Such plates are expected to give valuable assistance in micrometric work with the 16-inch Clark Equatorial.

The plan is to attach this new photographic camera to the tube of the old 11-inch refractor, now mounted in the Mitchell Memorial Building.

Jupiter casting a Shadow. About the middle of November, while the dome was darkened for the purpose of photographing stars with the 24-inch telescope, I noticed a rectangular patch of light on the floor, which on looking up I found to be caused by the planet Jupiter shining through the opening in the dome. The direction and definite outline of the patch left no doubt that it was the light of the planet and not that of stars. I have observed the phenomenon under the same conditions several times since, and once saw my shadow cast by the planet on the snow outside. Although it is not unusual for Venus to cast a perceptible shadow, I know of no other similar instance in the case of Jupiter.

Lowell Observatory, J. C. DUNCAN.
Flagstaff, A. T., Dec. 30, 1905.

The Nature of the Latent Image in Photography. While Dr. H. C. Wilson was in North Carolina observing the total solar eclipse of May 28, 1900, he succeeded well in getting a photograph of the solar corona as a whole, an exceedingly difficult thing to do, if at a single exposure it is desired to bring out the detail of the inner corona and, at the same time, expect to get the extended faint outer corona. The inner corona is dazzlingly bright, while the outer corona extends far outwards from the Sun, gradually growing fainter until it entirely vanishes. The exposure, above referred to, was made by an 8¼-inch photographic telescope for five seconds, and the problem was to get out of that plate so exposed all there was in it, by proper development and copying. After weeks of work on it to bring out whatever was masked in it, to the surprise of all interested the complex and beautiful detail in the inner corona and the faint long streamers of the outer were plainly shown in marvelous way. The real surprise came from the supposition that long exposure of bright parts would necessarily destroy detail and not mask it, and contrarywise short exposure of faint parts would not do work enough on the film to be worth anything in forming images of details. In both of these suppositions we were wrong in this instance

at least. Since that time we have done some thinking on the nature of the latent image of a photograph and the possible ways of explicit development. We conclude that the theme is too intricate for anything like a general helpful statement about it for general use.

To our delight we have noticed that practical photographers have been giving attention to the same thing in other countries, and that recently a strong paper was read before the Viennes Academy of Sciences. We have seen an extract of that paper in the *British Journal of Photography* for December 1, 1905, in which the nature of the organic and the inorganic images were studied as well as the physical development of the primary image. This article treats the matter both from the side of chemistry and also from the side of practical and experimental photography.

Royal Irish Academy Proceedings of 1904. In our reading one study by Professor J. L. E. Dreyer, Director of Armagh Observatory had escaped our notice. Though late, brief notice of it may be of service to some. The title of the paper is "A Survey of the Spiral Nebula, Messier 33, by means of photographs taken by Dr. Isaac Roberts." The first part of the paper is taken up with a brief historical statement of what astronomers have said and done concerning this object from Herschel's notice of it in 1785 to the present time. He then speaks of the defects in drawings and micrometrical measures, and turns to photography as furnishing great advantages over direct micrometric measures. The reason offered for this is that the plate covers a larger area than the micrometric screw can range over, and therefore offers a larger selection of comparison stars, while it at the same time enables the observer to measure these without taking transit and thereby introducing systematic errors. Nobody has yet succeeded in finding a nebula having proper motion or annual parallax, and yet it would be of the greatest value for our conception of the universe if discoveries of this kind could be made, on account of the very peculiar distribution of the nebulæ over the heavens, the great majority of them being masses near the poles of the Milky Way, while one peculiar class, the nebulæ having gaseous spectra, nearly all lie in, or close to, the Milky Way". This strange and very interesting fact may become very important, as the study of these unique celestial bodies goes forward in the future.

For reasons that are obvious, the photographic method was chosen and the remainder of the paper is occupied with the details of measurement and explanatory notes to accompany the work. The result of the work appears in a large skeleton chart of the nebulæ which furnishes a basis of reference for future study that will prove most valuable.

Jupiter's Family of Comets. One of our highly esteemed friends across the ocean has been kind enough to suggest, that POPULAR ASTRONOMY put out a new edition of the plate showing the present state, as far as known, of the large family of comets belonging to Jupiter. Some of our readers will remember that such a diagram, on a large scale, was published in 1893, and a brief article accompanied it giving a description of the method employed in constructing it. The work was actually done by a student in Carleton College.

Concerning the chart our correspondent was kind enough to say: "I have always found the old diagram very useful. A new one would be very much more so owing to its completeness." If we can possibly find the time to do this needed work, or have it done, by some trusty hand, we shall be only too glad to comply with this suggestion.

Royal Medal to Professor Poynting. The Royal medal is awarded to Professor John Henry Poynting, F. R. S., on account of his researches in physical science, especially in connection with the law of gravitation.

Professor Poynting is distinguished both in theoretical and experimental physics. His memoir, *Phil Trans.*, 1884, "On the Transfer of Energy in the Electromagnetic Field," contains the fundamental proposition which is now universally known as Poynting's theorem. It was followed in *Phil. Trans.*, 1885, by a paper "On the Connection between Electric Current and the Electric and Magnetic Inductions of the Surrounding Field," which works out the current circuit on the supposition of motion of what are now called Faraday tubes. These papers served greatly to elucidate Maxwell's Theory, and to give a representation of the physical nature of the electric field which is now widely utilized. His long continued experimental and theoretical researches on the constant of gravitation, and on the mean density of the earth are reported in a paper in the *Phil. Trans.*, 1892, and in the Adams prize essay for 1903. Closely related to this subject is an experiment in search of a directive action of one quartz crystal on another, *Phil. Trans.*, 1899, which though leading to a negative result, is a model of the application of refined methods to a physical research of great delicacy. His recent paper, *Phil. Trans.*, 1903. "On Radiation in the Solar System, its Effects on Temperature and its Pressure on Small Bodies" is of great interest and significance to cosmical physics.—*From Nature, Dec. 7, 1905.*

Books and Pamphlets Received. Annuario Astronomico pel 1906, Turino.

Osservazoni Meteorologiche 1904, Turino.

L'Annuario Astronomico. 1905, Turino Osservatorio.

Total Solar Eclipses of 1882 and 1905 Compared. J. Y. Buchanan in *Nature* December 21, 1905, makes an interesting comparison between the eclipses of 1882 and 1905:

"If we assume that the argument from parallax is applicable to the inner corona, as it is to the protuberances, we have to conclude that eight seconds before second contact, the light-giving portion of it did not extend further than between 93″ and 94″ from the western limb of the Sun. To an observer on the central line, at mid-totality, it is eclipsed to a distance of 45″ from the Sun's limb, and this would leave only between 48″ and 49″ as the width of the outer portion, which furnished the unexpected amount of light which persisted through totality. It is clear that if the inner portion, having a width of 45″, had been uncovered, the daylight during totality would have been still more remarkable."

"In this respect there was a great contrast between the eclipse of this year, and that on May 17, 1882, which I witnessed at Sohag, on the Nile, where a lagre camp of astronomers of many countries was established. In it, one of the most striking features was the rapid darkening during the last moments before second contact. I have always compared it to what is witnessed when a lecture room is darkened during the day by quickly closing the shutters of the windows in succession. In 1882 the darkening took place rapidly and completely; and immediately quite a number of stars came out, besides the great comet which revealed itself, all unsuspected, close to the Sun's limb, and formed a feature of that eclipse which was most noticed and best remembered by the spectators. In 1905 the darkening effect was much less striking: but the illustration of the lecture-room holds if we imagine that the shutter of the last window is out of order, and has to remain open during the demonstration."

"The contrast between the two eclipses is accentuated when we remember that the apparent semi-diameter of the Moon, as seen from Torreblanca, was 45″ greater than that of the Sun, while on the Nile this excess was only 15″.4. Therefore a width of 45″ of the brightest part of the corona was eclipsed in 1905, as against only 15.″4 in 1882. If therefore, the uneclipsed coronas had possessed equal efficiency as furnishers of daylight, the darkness during totality ought to have been much greater in 1905 than it was in 1882. But the opposite was the case. Therefore, whatever may be the process by which the inner corona or luminous ring is produced it was much more active on August 30, 1905 than it was on May 17, 1882."

"The observations of the solar eclipse of 1905 here referred to were made at Torreblanca, Spain, which point was about one mile northeast of the central line of the eclipse. The position was in lat. 40° 12′ north, and long. 0° 12′ east of Greenwich. Time of totality was one minute and fifty seconds. Totality began at 1^h 8.5^m and the Sun was then 54°.5 high. The observations of this eclipse ought to be very useful because the Sun was in the midst of its maximum period of spottedness. Some student of solar physics ought to work up the data now on record, about the conditions of the Sun at the maxima and minima of sunspot activity, to learn what help may come from solar eclipses in the study of the Sun." The above extract is important as bearing on the light of the corona.

Annual Report from Cambridge Observatory (England). Points in the study of Eros at Cambridge Observatory are interesting. "The object of this investigation was two-fold, first, to find what degree of accuracy is obtainable in combining photographs taken at various places, with different instruments, and especially to examine the nature of the systematic divergences that occur; and second, to make a preliminary determination of the solar parallax from this block of material with a weight equal to that of the best existing determinations". This discussion was based on 295 photographs from nine observatories and the value of the solar parallax obtained was

$$8''.797 + 0''.0047$$

a good agreement certainly with the best observational results. The apparent probable error is also favorable.

The work of the Meridian Circle has been the observation of more than 2000 stars of the Gill Zodiacal Catalogue, 200 of which are continually observed as they are fundamental stars. There remains yet 381 to complete the work, the 67 stars remaining being too far south for observation at Cambridge. Photographic work by the equatorial on the parallax of stars has been in operation by Mr. Hinks and Mr. Russell. Generally each plate has four exposures, the bright stars through a screen and the fainter ones without a screen. Twenty-five have been observed in the first way and twenty-nine in the second.

The equatorial used has recently been mounted in the novel and untried polar siderostat form. It has been otherwise modified to make it quite equal to the standard astrographic telescopes. Those who have used it are quite satisfied with its work.

The Newell telescope has been devoted to spectroscopic study of stars in the line of sight. Mr. Bellamy has taken 131 photographs, including 44 of 10 velocity-reference stars in coöperation with other observatories; 43 of 12 typical bright stars for study in the green part of the spectrum and 44 of 16 stars for the study of the spectra and of the velocity in the line of sight.

Naval Observatory Superintendent's Report. The report of C.

M. Chester, Rear Admiral of the U. S. Navy, is at hand. The following changes among the officers have taken place during the fiscal year ending June 30, 1905:

Commander J. M. Robinson U. S. Navy detached June 30; Lieut. Com. J. D. Griffin, U. S. Navy reported for duty June 7; J. H. Root resigned, as Assistant April 21; G. B. Merriam as Assistant; Arthur Snow promoted as Assistant; H. B. Evans transferred from Assistant to piecework; A. B. Turner transferred from computer to miscellaneous computer; C. W. Fredrick transferred from Assistant on Equatorial to Assistant astronomer, Tutuila Observatory, naval station, Tutuila, Samoa; E. D. Tillyer promoted as Assistant; W. W. Dinwiddie promoted from Assistant in spectroscopic work to computer; Matt. Fredrickson transferred from miscellaneous computer to assistant on equatorial; Arthur Newton, promoted from piecework computer to Assistant; Charles N. Moore transferred from miscellaneous computer to Assistant in spectroscopic work; L. G. Hoxton appointed assistant; Edwin C. Howell appointed miscellaneous computer, later promoted to assistant; Asaph Hall, Jr. appointed miscellaneous computer; Benjamin Boss, same.

The plan of work for the last year has been as follows:

"*Equatorials.*—To make observations of the satellites of Mars, Jupiter, Saturn, Uranus, and Neptune when the planets are not more than three hours from the meridian; satellite work is to take the precedence of all other work; observations of occultations of stars by the Moon; observations of comets; photographic search for asteroids; and observations of double stars in intervals unoccupied.

Meridian instruments.—To make observations of the Sun, Mercury, and Venus at every culmination, except Sunday, whenever possible; of the Moon at every culmination, except between 8 A. M. and 5 P. M. on Sunday, whenever possible; of Mars, Jupiter, Saturn, Uranus, and Neptune, when in the vicinity of the Moon, to the extent of obtaining 30 observations of Mars and 15 each of Jupiter, Saturn, Uranus, and Neptune; of miscellaneous stars when requested; of a catalogue of 3,000 zodiacal stars; and when not interfering with the work above outlined, of stars from Newcomb's Suggested List of Fundamental Stars.

Prime vertical.—To make observations of four groups of stars, four stars in each group, α Lyræ and θ Aurigæ to be included by the polygon method.

Alt-azimuth.—To make observations of the stars of Newcomb's Suggested List of Fundamental Stars culminating here at zenith distances less than 75°.

Photoheliograph.—Daily photographs of the Sun, when possible, with temperature readings and scale settings, and preparation for future eclipse work.

Two other prominent features appear in this report, one regarding the time service, and the other the establishment of a new branch observatory at Tutuila, Samoa."

The vigorous campaign of the Superintendent of the Naval Observatory and others interested to bring about speedily a universal standard time system for the entire civilized world, has made some impression at home and abroad. This has been accomplished mainly through special midnight signals to all parts of the world, also by circulars of information, and especially by a monograph with the title: "Present State of the Use of the Standard Time", by Lieut. Com. Hayden as published in App. IV to Vol IV of the Publications of the Observatory.

The other feature, the building of a branch observatory in Samoa is a most worthy step for Astronomy, because an observing station at such a place as Samoa will furnish astronomical data that is much needed, covering a zone from the south pole of the heavens to a north latitude beyond the zenith at Washington. America and England independently and permanently in Astronomy from pole to pole!

Exercises in Geometry by Conant. The American Book Company have just published a new book on original exercises in plane and solid geometry which was prepared by Levi L. Conant, Ph. D., Professor of Mathematics in the Worcester Polytechnic Institute.

It consists of 124 pages, and contains 900 exercises. Its definitions and figures were needed and seem to be all that could be desired.

The author has sought to obtain variety in these exercises combined with proper gradation from easy to difficult problems; to generalize whenever it was possible, in other words, to gather up in one problem as many kindred problems as seemed judicious, to interest the student in the history of geometry and to teach from time to time new principles.

The author makes one statement that we can heartily commend, and that is, that he has solved all the problems in order to test their fitness for the class work for which they are intended. If those who write text books in elementary or the higher mathematics would do the same thing faithfully, teachers would have immeasurably less trouble in using new books than we know they now have.

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Astronomical News.—It is very much desired on the part of the management, that brief news paragraphs of astronomical work in all the leading observatories of the United States be furnished to this publication, as regularly and as often as possible.

The work of amateur astronomers, and the mention of "personals" concerning prominent astronomers will be welcome at any time

The building and equipping of new observatories, the manufacture, sale or purchase of new astronomical instruments, with special reference to improvements and new designs, and the results of new methods of work in popular language, will be deemed very important matter and will receive prompt attention. It is greatly desired that all persons interested bear us in mind and promptly respond to these requests.

Messrs. Wm. Wesley & Son, 28 Essex Street, Strand, London, England, are our sole European agents.

Reprints of articles for authors, when desired, will be furnished in titled paper covers at small cost. Persons wanting reprints should order them when the manuscript is sent to the publisher. They cannot be furnished later without incurring much greater expense.

Subscription Price Changed. Beginning with the January number the price of Popular Astronomy a volume, of ten numbers each, to subscribers living in the United States, its territory, Canada and Mexico was changed to $3.50; the price to all others is $4.00; in each case payable strictly in advance.

Back volumes or single numbers are still on sale at the old prices, $2.50 and 30 cents, respectively.

WM. W. PAYNE,
Northfield, Minn., U. S. A.